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THE LIGHTING OF THEATRES.

BY the opening last week of the Garrick Theatre, an addition has been made to the number of buildings in London devoted to public entertainment which are lighted by the electric light. The example was set some years ago by the Savoy Theatre, in which both the stage and auditorium were electrically lighted, a matter which was at that time quite a novelty, and the Criterion and Prince of Wales followed suite. Gradually since then other theatrical managers have found it to be to their interest to adopt the light, and theatre-goers have experienced a most direct benefit by the progress which has been made in this direction. It is somewhat strange to contrast the present methods used with those which playgoers used to have to endure. Pepys, in his diary, 12th February, 1667, records the great improvement which had been made in stage lighting. Whereas at one time "not above 3 lbs. of tallow" was employed, there were then "wax candles, and many of them." Oil lamps afterwards took the place of candles, and early in the present century gas, in its turn, superseded oil. The late Dutton Cook records in one of his books on the stage, that in 1828 an explosion took place in Covent Garden Theatre, by which two men lost their lives. Great alarm was excited. The public were afraid to re-enter the theatre. The management published an address, in which it was stated that the gas fittings would be entirely removed from the interior of the house, and safer methods of illumination adopted. The employment of gas in theatres was strenuously opposed by many, and one medical authority wrote a long remonstrance on the subject, stating that the gas produced headache and giddiness. There was, perhaps, some truth in this statement. The atmosphere in some of the London theatres, the owners of which are either too antiquated in their ideas or too hard-up in pocket to abolish gas, is often stifling. The policy is a short-sighted one. People who feel comfortable in their seats will be far more pleased with a play than if they are stifled by the hot fumes rising from numerous gas jets. In addition, there is the question of safety from fire, and the consequent reduction of insurance premiums, to put it from a purely monetary point of view. Happily for themselves, "behind the scenes" is an unknown world to most of those who are seated in front of the house. Could the audience in a theatre, the stage of which is lighted by gas, but see the risks of fire which are incurred, a large proportion of them—however inveterate theatre-goers they might be—would not enter the house.

"Where ignorance is bliss, 'tis folly to be wise," is a maxim true enough in some cases, but it hardly applies in this instance. A paper has recently been read before the Illinois State Association of Architects on "Stage Mechanism," by Mr. Dankmar Adler, who had inspected the principal theatres in Europe. He stated that in London he had visited five new theatres in process of erection, and considered their arrangements admirable; and it may be pointed out here, though not mentioned by Mr. Adler, that all the new theatres in the metropolis are supplied with electric light. At the same time, he expressed the opinion that in London the theatres, as they increased in size, decreased in safety. This remark is, on the whole, true. Small theatres, such as Terry's, the Prince of Wales, and Criterion have the electric light. The large ones have not. Drury Lane has the electric light on the stage, but not in front. Covent Garden has only had spasmodic temporary installations. Her Majesty's is content with gas. The Standard and Britannia, large theatres in the East End which draw the masses, have no electric light. "'Tis true, 'tis pity, pity 'tis, 'tis true." Another prominent example is the Lyceum Theatre. The lighting arrangements of this house, excepting one or two dressing rooms which are electrically illumined, are of a most crude description. From the balconies and boxes project gas lamps which appear to be specially designed as receptacles for programmes falling from above. It is

well known that it requires but little to create a panic in a crowded house, and the Lyceum is usually, and, we think, deservedly so, very full. In addition, though a fair-sized house, there are only three exits; one from the gallery, one from the pit, and a third by which the occupants of the boxes, stalls, dress circle, upper circle, and amphitheatre all come out. On ordinary occasions the crush in this lobby is bad enough, and there can be no doubt that should an alarm of fire arise that the most serious consequences would result. In view of the existence of such dangers in London theatres, of which this will serve as an instance, it would be well that every manager should do away with the perils of gas lighting, and adopt the safer and more pleasant electric light, and this we learn that Mr. Irving will shortly do.

AT the meeting of the Académie des Sciences, of the 23rd ult., under the presidency of M. des Cloizeau, M. Janssen presented to that body Mr. Edison's new perfected telephone. After having pointed out what the primitive apparatus was like ten years since, and the successive modifications and improvements undergone by it, M. Janssen enumerated the latest improvements.

COLONEL GOURAUD spoke after M. Janssen and gave the history of the phonograph, insisting on the rare spirit of invention with which his friend, Mr. Edison, had pursued its improvement. Colonel Gouraud himself used it daily as a shorthand writer. There was also every evidence that in business it was coming greatly into use on account of its unparalleled rapidity of execution. It was speaking letters which were now sent by its means. From New York to Philadelphia, 140 kilometres, a letter of that nature was enabled to be sent instantaneously to its destination by the combination of the new phonograph with the different telephones, which were also due to Mr. Edison's inventive genius. Colonel Gouraud finished his speech by some practical illustrations of the use of the phonograph; among others he produced to the Académie some words spoken by M. Gounod in the *Salon* of M. Berger and an eclectic programme composed of "Partant pour la Syrie," and "La Marseillaise," executed on the cornet-à-piston. On account of the great importance of this communication, the Académie, on the proposition of its President, decided that four pages should be devoted to it in *Comptes Rendus* instead of two, the latter being the usual number, from which it is evident that the gallant Colonel has scored heavily in *La Belle France*.

THE French journals devote considerable space to these (for France) novel experiments. From among them we extract the following particulars taken from Colonel Gouraud's speech as to the uses to which the phonograph may be put:—1. One can dictate correspondence and have it transcribed at leisure by a clerk who need only know how to write and spell correctly; one can have it transcribed by typography, or have it printed directly. 2. One can transmit his voice by post by means of a phonogram. The voice of he who speaks is heard with its own inflexions. 3. Statesmen, lawyers, preachers and orators can study their speeches, having the inestimable advantage of registering their ideas in proportion as they present themselves with a rapidity which articulation alone can equal; they can especially hear themselves speak as others hear them. Actors and singers can repeat their *rôles*, and are able to correct their articulation and pronunciation. Journalists can speak instead of writing their articles which can be printed directly. The voices of celebrated men can be preserved indefinitely, as well as the last farewell of one dying, or the words of a relative whom one loves. In order to give you a real idea of its utility, I need only tell you that since I have arrived at Paris I receive every morning a speaking letter, giving me the details of what goes on at home in my absence. I was able to hear the last which I received at a distance of nine and three-quarter feet without losing a single word of it. What better idea can I give you of its usefulness than by telling you that I use it every day as a shorthand writer, dictating my answers to my letters, when I read them, and then passing it to my clerk, who transcribes what he hears.

THERE is in *Financial Truth*, of April 27th, an amazing article on the London Electric Supply Corporation's works. The following extract must, notwithstanding our limited space, be preserved to the electrical world:—"Electricity, like most forces in nature, appears to have its sexual arrangement, and it is curious to remark that the most economic product of intense force is obtained by the use of what are called "exciting dynamos," small machines of different construction placed opposite the larger dynamos. At Deptford these lady-loves (as we may call them), to arouse the amatory enthusiasm of the cumbrous males, are manufactured by W. H. Allen, of London."

THE squabble between two rival medical electricians, the details of which we publish on another page, is not calculated to raise such practitoners in the estimation of the public. It appears to be another example of the "pot calling the kettle black," for the termination of the case is as ludicrous as the cause which led to it. Happily there are men amongst us who quietly, but successfully, show what good can be accomplished by a rational and scientific method of applying electrical treatment to maladies which are considered more or less incurable, and the paper which we publish this week on the arrest of cancer growth is an instance.

THE *Temps* has just given some particulars about the position of the question of uniting Paris and London by telephone. That there are difficulties to be overcome our readers perfectly understand, but all of us were not aware of the strange part with which the *Temps* credits a submarine cable in the act of telephony. "The heart of the submarine cable," says our contemporary, "is a bundle of copper wires enveloped in a layer of gutta-percha. The whole is re-covered with a mattress of jute and a coating of twisted iron wire. By a still inexplicable particularity the layer of gutta-percha is permeable underground or beneath water, leaving the electric current in contact, so to speak, with the coating of iron wires, which then play the part of telegraphic wires in the air, and exercise a retarding influence on the current. A certain portion of the electric current is thus absorbed by the coating of the cable." Furthermore we are informed that the "problem of transmitting by cable in a regular manner the electric transmission of the voice has yet to be solved. M. Amiot has shown that every time an electric current is sent along a cable, an effect of inertia is

produced which paralyses, almost completely, the evil effects of the cable. He is engaged in developing this inertia, but the result of these long and minute studies has yet to be awaited." One might almost think that the electrical writers in the *Temps* and our own *Times* were closely allied, if not one and the same individual.

IN the abstract of Dr. Lawson's paper on deaths from lightning in England and Wales, which we published last week, it was noticed that Essex, Norfolk and Suffolk were counties having a high death ratio. *Apropos* of this we observe that during a thunderstorm, which passed over the last named county on Wednesday last week, a man and two horses at work in a field at Weybread were instantly killed.

WE have received an anonymous communication upon the subject of armoured *versus* unarmoured cables, or to be more accurate, our unknown correspondent (who calls himself "anti-humbug") writes, not so much upon the respective merits of these types of cable, but indulges in a most vigorous onslaught upon Captain Trott and his friend Judge Weatherbee; in fact the article is distinctly libellous. Apart from other considerations, even had the author conformed with the usual requirements as to signature, we do not see that any fresh light is thrown on the question of submarine cables, or that any benefit to submarine telegraphy could result, from the publication of matter of such description as the communication we refer to. Although Judge Weatherbee has rather "given himself away" in a too zealous and ill-considered advocacy, and though we think that Captain Trott is wrong in jumping too hastily to certain conclusions, yet, so far as we know, neither of these gentlemen has said or done anything to merit a purely personal attack.

AS the Elieson Electric Company failed to find buyers of their patents and plant at the recent attempted sale, is it too much to suggest that some means should be devised to bring about a reorganisation of the company's affairs? Surely, Mr. Vincent, its solicitor, or the worthy secretary, can find a way out of the difficulty! In the meantime, as we have previously urged, some facts should be laid before the public to account for the failure of the company to successfully engage in electric traction from the commercial point of view. If it can be clearly shown that the collapse is not attributable to any defects in the matter of electrical haulage, then surely means might be provided to carry on operations under more careful management. We can only conclude that the prospects of other companies which are trying to promote the employment of electricity on tramways will not be enhanced while the causes which have led to the Elieson failure remain buried in obscurity; and it would assuredly be to the benefit of all concerned in electric locomotion, and to the Elieson Company in particular, if all the incidents which have contributed to the present position could be brought to light.

THE Board of Trade enquiry into the electric light Provisional Orders has had the effect of inciting every periodical, whether of a scientific or non-technical bent, to give its views on the situation. The following extract from the *Referee*, which not long ago made itself extremely ridiculous in its nonsensical attacks upon M. Pasteur, is a good sample of its kind:—"As regards electric lighting, a vast amount of experimenting has still to be gone through before the ideal will be reached. Until some method can be discovered for producing electricity without burning coal—in other words, for converting the coal first into gas and then into electricity—the electric light must necessarily be dearer than gas." It is evident that the writer intended to convey to his readers the impression that electricity must be produced by the direct combustion of coal, and without any intermediary appliances; as it stands, the paragraph is absurd.

WE give particulars of the Garrick Theatre lighting on another page. This installation has been carried out under the direction of Mr. Rashleigh Phipps, whose former experiences of theatrical architecture, under his father's guidance, have naturally been of the greatest service to him. Indeed, it stands to reason that to fit up these places of entertainment in the most effective style with incandescent lamps, it is necessary that the contractor should be conversant with all the ins and outs of theatrical requirements, both before and behind the scenes, and these Mr. Phipps possesses in no ordinary degree. We have ourselves gone over the Garrick under that gentleman's able guidance, and can vouch for the artistic nature of the fittings, while there is no reason to suppose that the wiring, which is carefully hidden from view, is not of the most substantial and reliable nature.

THE project of an Engineer's Institute, which is so eloquently advocated in the latest issue of *Electrical Plant*, merits attention; but, at the same time, so far as we can see, the idea that such an institute is required is more imaginary than real. Much of that for which our contemporary pleads is now available in the home of the Civil Engineers, and it is very doubtful whether that powerful body would join hands with the two other societies mentioned, to carry to finality the scheme of a national assembly of engineers, for it now occupies a proud and affluent position, which it would not care to merge into a portion of something else which might, or might not, come up to the ideal of *Electrical Plant*. We may probably touch upon this topic more fully in another issue; but, at the moment, it seems to us that the suggestion may be compared to a sort of perpetual British Association meeting, where for the nonce, as we all know, the various branches of the engineering professions are congregated in one common centre.

THE annual spring meeting of the Institution of Mechanical Engineers commenced on Wednesday evening, and was continued last night, terminating this afternoon. In view of the fact of recent important electrical work such as, for example, the Deptford Central Station, being largely associated with mechanical problems, and also bearing in mind that both the Institution of Civil Engineers and the Institution of Mechanical Engineers having of late shown that they recognise the necessity of engineers in general paying attention to the younger branch of science, it was rather surprising that the President, in the course of a pretty long address, did not devote a little more attention to this department of engineering progress. The principal reference, though even this was not very prominent, was that electricity has come to the aid of the mechanical engineer in our short railway systems, giving promise of larger and more general application when circumstances favour its cheap production by proximity of waterfalls or low cost of fuel.

UNDERGROUND ARC LIGHT WIRES IN NEW YORK.*

By SCHUYLER S. WHEELER, Sc.D.

WITHIN the last few weeks arc lights have been put in operation with underground cables for the first time in New York City. The subways which have been in readiness for some time have been found thoroughly practicable for telegraph and telephone wires, and they have been put into use extensively for these wires, there being now upwards of 5,000 miles of such wires drawn into the subways. But the practicability of operating electric lights requiring high pressure currents has been denied on all sides by the electric light interests. Consequently, when the electric light companies became satisfied that they would be compelled to remove their overhead wires from the principal streets of the city within a fixed period, they claimed the right to make a test of the subways and of such cables as could be obtained for the purpose of determining whether their business could be carried on in them, and also to gain some little experience before the final order for the removal of their overhead wires should be given. This demand was met and provided for by giving the various owners of circuits extra time in which to make a commencement by laying cables in a particular locality to form sections of their respective circuits, as these would at the same time serve as a test.

The action taken under this permission for preliminary work has been different in the case of each company, varying with their respective policies and requirements. The Brush Company were the first to take action in the matter, and as they had a number of circuits taking a straight course up Broadway they ordered and laid last August a cable on Broadway from 14th to 35th streets, containing eight conductors which would take eight of their circuits through one tube of the subway.

The next cable was laid in January through 125th Street, by the Harlem Electric Light Company over a short route. This cable was completed immediately and put into use, running arc lights. It has been in satisfactory operation ever since.

Single conductor cable was used for this, as well as for all other lines laid, since the Brush cable was ordered. The next cables were short length, laid in February 24th and March 25th respectively by the Manhattan Electric Light Company to connect their wires to Proctor and Turner's Theatre, and to the Union Square Theatre. And last, the current was turned on, April 4th, to the arc light cables laid by the United States Company extending over the triangular route, formed by Broadway, 23rd Street and 6th Avenue, a distance of 1¼ miles.

At about the same time the Manhattan Company turned their incandescent current of 1,000 volts into cables laid under both sides of Broadway from 14th to 34th streets, a length of about 3½ miles. All of these cables, excepting the Brush, have been working continuously since they were started, with great success. In the case of the Brush Company's cable, the eight conductors required for the route were made into one cable, because that disposition of the conductors required much less space in the subway. When this cable was submitted to the technical representatives of the Board of Electrical Control, it was at once seen that the insulation between the conductors would be considerably less than it would be if they were made up in separate cables. And apprehending that this might be a point of weakness, a new rule, which was afterwards adopted by the Board and by the Subway Company, was recommended, limiting the difference of electromotive force, which should be allowed between several wires when made in one cable, to 500 volts.

This required that the opposite "legs" of an arc circuit should be carried in separate cables. It was also suggested that it would be more difficult to attain the same high degree of insulation between conductors thus enclosed in one covering. Being the first heavy cable of the kind ever laid, a longer time was consumed in completing it. Since completion it has been tested with the greatest care with the following results, and possesses, as may be seen, a high degree of insulation, notwithstanding some reports to the contrary which have appeared in the press :—

TESTS OF BRUSH EIGHT-CONDUCTOR CABLES BY WM. MAVER.

Length of Cable, 11·5 *Miles.*

Insulation between each Conductor and Ground.

No. of conductor.	Total insulation resistance.	Insulation resistance per mile.
1	380 megohms.	414 megohms.
2	380 „	414 „
3	400 „	460 „
4	360 „	414 „
5	400 „	460 „
6	400 „	460 „
7	288 „	331 „
8	262 „	301·2 „

Insulation between each Conductor and all the other Conductors connected to ground.

Number of conductors.	Total insulation resistance.	Resistance per mile.
1 with 2, 3, 4, 5, 6, 7, 8, to ground.	350 megs.	402 megs.
2 „ 1, 3, 4, 5, 6, 7, 8, „	350 „	402 „
3 „ 1, 2, 4, 5, 6, 7, 8, „	350 „	402 „
4 „ 1, 2, 3, 5, 6, 7, 8, „	350 „	402 „
5 „ 1, 2, 3, 4, 6, 7, 8, „	350 „	402 „
6 „ 1, 2, 3, 4, 5, 7, 8, „	350 „	402 „
7 „ 1, 2, 3, 4, 5, 6, 8, „	87 „	100 „
8 „ 1, 2, 3, 4, 5, 6, 7, „	77 „	88 „

The delay in putting this cable into use has resulted from the fact that while the insulation of all of the conductors of the cable is fairly good, the last two conductors do not possess an insulation quite as high between wires as is required by a strict interpretation of the stringent rules of the board.

The line in 125th Street, 2,000 feet in length, is laid in the small ducts of the Johnstone system of conduits. The cable is a white core Bishop's gutta-percha cable, which was found ready in the market, and was laid immediately after the order for the work was given. The cable was connected to overhead arc light wires by running it up in a 2-inch iron pipe fastened to the outside of an ordinary city electric lamp post. Connections were made with lights in front of stores by carrying the cable from the ducts in iron pipes under the sidewalk and up the fronts of the stores. This line has been in continuous use for two months, carrying a pressure of 2,500 volts, and it shows an actual rise in insulation with age and use, as will be seen from the following test :—

January 11th, 1,100 megohms.

February 11th, 1,800 megohms.

April 12th (including eight arc lamps and branch leads), 2,600 megohms.

The cable laid in Sixth Avenue and 24th Street, 1,200 feet in length, to connect with Proctor and Turner's Theatre has been in continuous use since February 24th, carrying 1,200 lights, with an alternating current of 1,000 volts. The tests of this show insulation as follows :—

February 24th, 150 megohms.

March, 300 megohms.

The cable was laid in a special conduit in 24th Street, which was built in three days after permission for overhead connections had been refused. The cable used was partly Bishop's and partly that of the Standard Underground Cable Company.

The cable in 4th Avenue, 220 feet in length connecting the Union Square Theatre, was also laid in a special conduit built for this purpose within one day. In this place the safety insulated cable was used and the current carried is 1,000 volts alternating, supplying 1,300 lamps.

This cable when on the reel before laying tested

* New York *Electrical Review.*

9,000 megohms. Immediately after laying tested 100 megohms weaker, being damp; now it tests uniformly.

The policy of the Manhattan Electric Light Company being to push ahead with their business on an all-underground basis where possible, they went ahead at once, and laid pairs of conductors on Broadway from 14th to 42nd Streets on the west side, and from 18th to 25th Streets on the east side, and on Sixth Avenue from 18th to 58th Streets. Of these lines the following were connected up on April 3rd, and supplied with the alternating current of 1,000 volts from their station at 80th Street through wires strung on the new model overhead electric light line on First Avenue:—"West side of Broadway, 14th to 32nd Streets; east side of Broadway, 25th to 34th Streets." The total length of the cable, about 3½ miles when connected up, had an insulation of 370 megohms, which was reduced to 22 megohms when the converters and other appliances were connected on. The subsequent tests given below have been made without disconnecting the 14½ miles of overhead wire leading from the station to the subway, and they show a decrease of insulation proportionate to the increase in the number of connections made from day to day.

TESTS OF THE MANHATTAN ELECTRIC LIGHT COMPANY.

Location of cable.	Weather.	Megohms.	Megohms per mile.	Date. April.
Broadway, 14 to 46, W. side } „ 25 to 34, E. „ }	fair	370	1110	3
„ with 15 converters in	clear, warm	22·2	66·6	4
„ in service over night	clear & fair	18·2	54·6	5
„ with pole lines ...	clear	12·85	321	8
„ „ „ ...	clear	13·3	332	9
„ with 24½ miles of pole lines all in	clear	8·93	279	10
„ and additional houses connected	fine	9	282	11
„ with cross connection at 17th, 25th and 27th streets, pole line to 80th Street and Ave. B, and 20 converters and subsidiary connections	mild, damp	9·13	...	13
„ „ „ ...	clear & dry	10	...	15
Cable on 6th Avenue, 25th to 33rd streets, and on 28th Street from 6th Avenue to Broadway, length ¼ mile. No subsidiary connections, 3	fine	2500	1250	14

The United States Company wishing to make a test of the subways and cables for arc lighting, laid three cables on Broadway from 30th Street to 23rd, through 23rd to 6th Avenue to 34th Street, and down Broadway to 30th Street again, to join their pole line which extends through 30th Street from Broadway to their station. Wishing to include a test of lamp connections, they mounted 10 arc lamps on the gas lamp posts, and led the wires up from the subway, through the inside of the posts. These lamps were all connected to one circuit. The reason for laying three cables was that it was easier to draw the others into the tube with the first cable than to draw them in separately afterward. The tests of these three cables when completed were: No. 1, 3,400 megohms; No. 2, 2,266 megohms; No. 3, 2,266 megohms. When the loops of cables for running up the lamp posts were connected to cable No. 1, the cable tested 588 megohms.

This reduction was owing to the many ends of the cable so formed being exposed to the atmosphere at the tops of the lamp posts. After the lamps were connected in the cables tested 111 megohms, the reduction being due to the increased effect of the same cause, *i.e.*, exposure. Enough current was then turned on to light the 10 lamps as an experiment, and as the tests the following day showed an increase of insulation, the electromotive force on the circuit was raised by adding lamps in the station until by successive increases each day the pressure was brought to the maximum of 50 lamps. The insulation was found to increase almost regularly each day, as shown by following Table.

Twice in damp weather the insulation was found to be temporarily very low, and this was proved to be caused by the exposure of the lamps and the ends of the cable, to the weather, whereby these portions of the underground system were subjected to the same loss of insulation that occurs in all overhead lines in such weather. This was proved by warming and drying the connecting wires at the lamps, by which the insulation of the whole line was completely restored, the weather being still damp. And it seems to be a proper conclusion that the only part of an underground line that will not maintain a very high insulation during storms is the part that is exposed for the purpose of making connections.

The tests made at the same time with the first-class overhead wires, used to connect the underground wires, showed that their insulation invariably fell in damp weather far below that of the cables, even when the latter were reduced by the dampness of the terminals, while, as stated before, when these terminals were properly dried the cables tested nearly as high in stormy as in dry weather.

TESTS OF UNDERGROUND ELECTRIC LIGHT CABLES OF THE U. S. CO.—ELECTRICAL EXPERT'S DEPARTMENT.

Location of cable.	Weather.	Megohms.	Megohms. per mile.	Date.
Cable No 1.—Broadway, 23rd Street, 6th Avenue and 34th Street. Length, 1·74 miles	Clear and cold.	3,400	5,780	March 30
„ With connections up lamp post	Clear.	650	1,131	April 4
„ Ten lamps connected in	Clear and fair.	111·1	193·3	„ 5
„ Aerial line, 1·98 miles, 90 megohms	Threatening.	...	251·2	„ 6
„ Aerial, infinity	Warm and dry.	275	478·5	„ 8
„ Aerial, „	Clear and dry.	323	562	„ 9
„ Aerial, „	Clear and pleasant.	175	304·5	„ 10
„ Aerial, not tested	Clear and warm.	375	652·5	„ 11
		Ohms.		
„ Lamp connections wet, time of testing... 9 a.m.	Threatening.	610,000	1,061,400	„ 12
„ Lamp connections wet, time of testing... 10 a.m.	Rainy.	200,000	348,000	„ 12
„ Lamp connections wet, time of testing... 10.45 a.m.	Rainy.	61,000	106,140	„ 12
4.30 p.m.		Megohms.	Megohms.	
„ Lamp wires newly paraffined	Overcast.	2·5	4·35	„ 12
		Ohms.		
„ Lamp connected to cable...	Overcast.	66,000	...	„ 13
		Megohms.		
„ Lamp not in circuit	Overcast.	150	261	„ 13
„ Lamps hung on insulators	Cloudy.	250	...	„ 14
„ „ „ „	Dry.	309	...	„ 15

THE ARREST OF GROWTH OF CANCER BY POWERFUL INTERRUPTED VOLTAIC CURRENTS.

By J. INGLIS PARSONS, M.D., Assistant-Physician Chelsea Hospital for Women.

IT may be said that I am premature in bringing these cases forward. The paucity of clinical material at my disposal must be my excuse. I might have to wait some time before again obtaining suitable cases for testing the principles brought forward.

The only patients that I have had an opportunity of treating have been those who were beyond operative interference, or too nervous to undergo an operation with the knife.

The method of treatment about to be described is based upon the following considerations :—

First, with regard to the nature of cancer. The earliest pathologists regarded it as a dyscrasia, or altered constitution of the blood ; then followed the embryonic cell theory ; finally, the microbe was made to bear the burden of further misdeeds.

Virchow, with his dogma, "*Omnis cellula e cellulâ*," demolished the first. The second, propounded chiefly by Cohnheim, will not account for all tumours, even if it be admitted as possible that embryonic tissue can remain for a quarter to half a century in the human tissues, without partaking in the changes undergone by other cells in the body. Thirdly, all attempts to find the microbe have failed.

The hypothesis now brought forward is founded on the fact that all the cells of the body possess a latent capacity which enables them, under various stimuli, to proliferate and form new tissue. Under normal conditions, this capacity remains dormant, or is only exercised to the extent of keeping pre-existing structures in a living condition. But let an injury or irritation to some part of the body occur, and this latent capacity ceases to be dormant, and an active formation of cells takes place, until the injury is repaired or the irritation removed. Now this formation of new tissue is essentially a new growth, although not a tumour. The capacity for forming it is common to all the tissues of the body, and it ceases when the necessity for its continuance has disappeared. This appears to show some controlling influence, probably by the nervous system. It is not, then, possible that all tumours are in the first instance composed of cells formed in the normal process of repair, but that, having escaped from the control of the nervous system, they take an independent life, and continue to proliferate and develop without check, just as all living cells are capable of doing *ad infinitum* under favourable conditions ?

The frequent association of cancer with a depressed condition of the nervous system is explained by this hypothesis. In other words, a tumour consists of cells which have sprung from the pre-existing cells of the body, but have escaped from the control of the system at large. The failure of even Virchow to find any reliable histological evidence in the early stages of a recent celebrated case points to the probability that the boundary line between the tumour new growth in its early stages and a normal new growth produced in the repair of an injury to the tissues is very indefinite. The close connection between the two is shown by some statistics in a recent paper by Dr. Gross,* who found that out of 907 cases of cancer of the breast there had been antecedent inflammation in 20 per cent., and a history of injury in 13 per cent.

Dr. John Williams found microscopical evidence of the gradual transition from healthy tissue into cancer in a case described by him in the Harveian Lectures.† At the same time, although devoid of nerves, all tumours have some sort of vascular arrangement, and continue to receive nourishment from the circulation. In this respect they are on an equal footing with the rest of the body. This appears to form a formidable barrier to any measures taken to stop growth through the internal administration of drugs. Whatever would affect the tumour cells would also affect the other cells in the body. Considering their origin and the similarity in composition between the cells of tumours and those of the rest of the body, it is unlikely that any drug will be found to exercise a selective influence on the former and leave the latter untouched. Unless this could be done, it would be necessary to damage more or less the whole of the body in order to get at the cancer cells.

There is one point, however, in which the normal cells of the body essentially differ from tumour cells. Most of the latter show a decided tendency to degenerate, while, in marked contrast to this, the healthy tissues possess wonderful recuperative powers, due probably to the presence of trophic nerves. It, therefore, seemed to me that if a cure were to be found for cancer it would be based upon this essential difference between healthy tissue and tumours, and that on account of this difference some agent might be found capable of inflicting an irreparable damage to a tumour, and yet stop short of destroying the normal cells of the body, on account of the higher recuperative powers possessed by the latter. And further, that, although the normal cells of the body are unable to resist the invasion of the cancer cells, the latter are actually of lower vitality. If such be the case, it may be asked, why should the cancer cells devour the healthy ?

The probability is that the difference in composition and structure between the malignant and healthy cells is not sufficient to stimulate the latter to resistance. Consequently, the proliferation of the cancer cells, resulting from their independent existence, enables them to overcome the healthy cells, since these, for want of sufficient stimulus, remain passive. In a paper read before the British Gynæcological Society in 1888, "On the Action of the Constant Current on Fibroid Tumours of the Uterus," I advanced the following hypothesis : "That while the normal tissues of the body have the power of recuperating any effect produced on them by the transport of elements, the cells of tumours being of lower vitality might be checked in their growth, and perhaps in time destroyed."

The following experiments were tried in 1887 to ascertain whether, when a current is passed through a tumour, any decomposition takes place between the poles. Three glasses were connected together with a stout lamp wick. Into each of these a standard solution of iodide of potash was placed. A current was then passed through the solution with an intensity of 200 milliampères, until the whole of the iodide of potash in the two outer glasses was decomposed. On testing the centre glass it was found to contain as much iodide of potash as before, although in the two outer glasses it was all decomposed. The resistance of this apparatus was so great that I was obliged to go to the Electric Apparatus Company, and do the experiment in the vaults of the Junior United Service Club, where an unlimited supply of volts could be obtained. A second experiment was then tried with water in the outer glasses and a solution of iodide of potash in the centre. The current was passed as before, but no decomposition took place in the centre glass. A third experiment was tried on the web of the frog's foot, and watched through the microscope. At the positive pole a coagulation took place, with exudation of blood from the capillaries. At the negative pole a collection of hydrogen bubbles could be seen. Between the poles no change could be observed, and the circulation went on as before. Finally, a strong current was passed through a fibroid tumour, soon after removal from the body, for a period of several hours. On making sections of the portion between the poles, no change could be detected. All these experiments demonstrated in a conclusive way that the passage of a constant current does not cause any decomposition between the poles, although there must of necessity be an exchange of atoms between the molecules. Recently, I have had

* *International Journal of Medical Science*, March and April, 1888.

† 1886 ; Case xv., p. 51.

an opportunity of examining sections of a fibroid tumour that I had thoroughly treated with a constant current, and which was subsequently removed by Dr. Travers on account of its size. No change could be found between the poles, showing that the conclusions drawn from the previous experiments were correct. Subsequent experience has shown me that repeated applications of the constant current, with an intensity of 200 milliampères, is unable to control the increase of a quckly-growing fibro-cystic tumour. But I noticed, in treating cases of fibro-myomata of the uterus by a constant current, that when, as occasionally happens, through an imperfection of the circuit, the current was suddenly interrupted, marked signs of disturbance followed, such as rise of temperature, considerable pain, and *malaise*. Rightly or wrongly, I put this down to some destruction of tissue occurring in the tumour, and, if this conclusion were correct, the means required for the treatment of cancer on the hypothesis advanced has been found.

The most probable explanation of this phenomena is that the impact of a powerful current, when suddenly flashed through, causes death of those tumour cells which lie in the nearest path between the poles where the lines of force are most concentrated, or else they are sufficiently injured to lead to their gradual atrophy. The latter explanation is more probably the true one, as no rise of temperature or other symptom follows the applications when applied to cancer.

Further than this, it has been ascertained by experiments on animals that even moderate voltaic currents suddenly interrupted could, when applied to the nervous system, cause death; while very much stronger currents applied to other parts of the body were found to be quite harmless in their action. If the normal cells of the body then differed so widely in their resisting power to electricity, it seemed more than likely that some difference would also be found between normal cells and those of tumours, although at first one might think the excess of resistance would be on the wrong side. For the treatment of fibroid tumours, anything likely to cause their wholesale destruction is to be deprecated. For this reason interruptions of the constant current have been carefully avoided, and precautions taken to gradually increase it as smoothly as possible. Being surrounded by a capsule, and having but few vessels in their interior, a gangrene *en masse* might follow, with all its attendant consequences. But this argument would not apply to cancer. Those cells, especially that most require to be destroyed, are scattered through the healthy tissues, and each little islet or bird's nest is surrounded by this tissue, furnished with vessels and lymphatics capable of absorbing it so soon as loss of vitality and degeneration occur. I therefore felt no hesitation in trying the destructive effects of a powerful interrupted voltaic current in the first case of cancer that objected to be operated upon in the usual way. After waiting a year or more the case presented itself. There is one point that, for want of space, I have not entered upon: Is cancer a local or a general disease? So far the accumulation of evidence appears strongly in favour of its being, at any rate, a local disease at first.

The *modus operandi* is as follows:—The patient is anæsthetised; the current is then passed through the tumour and all the tissues for some inches round it by means of fine, insulated needles, so as not to injure the skin. A battery of 70 cells, with an electromotive force of 105 volts, is used; the intensity of the current to commence with is 10 milliampères, gradually increased to 600 milliampères, and flashed through the growth in every direction from 50 to 100 times, according to circumstances. The pulse and respiration were carefully watched. One out of the four cases treated, a woman aged 63, with extensive carcinoma of the left breast, a presystolic *bruit*, and weak, intermittent pulse, was unable to stand more than 250 milliampères, and for this reason: When the current is applied to the left breast electrical stimulation of the heart occurs, and if this organ is healthy an increase in the strength of its contraction appears to take place after its passage; but with the patient who had cardiac disease the improvement only continued up to a certain point, and then the intermittency increased and great irregularity occurred.

These observations made last year on the human subject corroborate exactly those made in the laboratory on mammals by Dr. John McWilliam, and described in a recent paper in the *Journal*. He called the condition of the heart fibrillar contraction—that is to say, a widely inco-ordinated arhythmic contraction of the ventricular muscle, attended by a great and rapid fall of blood-pressure. It is only, however, in the immediate neighbourhood of the heart, and when it is diseased, that this takes place. When the current was passed through a secondary growth in the axilla of the same patient it could be increased to 600 milliampères with perfect safety.

The effects produced by the action of the electricity consist in a cessation of growth, gradual disappearance of pain, some shrinking and hardening of the tumour and enlarged glands, followed by improved nutrition and better state of the general health. The growth as a whole does not disappear, but remains as an inert mass, composed in all probability of fibrous tissue alone. Before treating these cases I felt almost sure that this would be the case, because I had found by a number of experiments detailed in the paper before referred to, and also from treating a large pelvic fibroma by galvano-puncture in 1887, that neither could electricity decompose the fibrous tissue of new growths (whatever it might do with cicatricial tissue), nor could the system cause its absorption after it had been rendered inert. However, it will always be open to patients to have the remains of the growth removed subsequently by the knife. The advantages claimed for this method of treatment are as follows:—

1. There is no destruction to the normal tissues of the body, and if recurrence should at any time occur, its progress can be immediately stopped, and the treatment repeated as many times as necessary. Life would by this means be prolonged indefinitely, provided that metastatic deposits had not occurred before the commencement of the treatment. So far, cases able to bear the full strength required have shown no signs of recurrence.

2. Patients are not obliged to lie up, but are able to get about on the day following the application.

3. The current can be passed through almost any part of the body, and thus arrest growths which could not by any possibility be otherwise treated.

Case I.—August 15th, 1888.—A. L., aged 38, married.

Present Condition: On the inner side of the left breast is a hard nodule, the size of a walnut, and a second one three times the size on the outer side, infiltrating the surrounding tissue. On the skin of the areola a distinct tuber can be seen; the nipple is also retracted. In the axilla are three enlarged glands. She complains of shooting pains in the breast and down the arm.

Diagnosis: Carcinoma of the breast. Mr. Bryant very kindly saw this case for me, and confirmed the diagnosis.

August 23rd.—Operation: Ether was given, and an interrupted voltaic current, slowly raised to 400 milliampères, was applied to the breast and tissue round in every direction. During the application the pulse became stronger, while respiration was not affected. At each make and break, the arm and shoulder were jerked up.

August 25th.—No rise of temperature or discomfort followed beyond a slight feeling of *malaise*. The pain has all gone.

August 30th.—Operation repeated.

September 15th.—The glands in the axilla treated in a similar way, and she was sent home.

October 18th.—No return of pain. The mass in the breast and the glands in the axilla are smaller and harder.

February 6th, 1889.—She still has no pain, and the condition of the growth remains unaltered. General condition excellent.

March 12th.—Patient continues to be quite well.

Case II.—September 26th, 1888. S. H., aged 62, married.

Present Condition: There is a large, hard mass involving the whole of the left breast, and extending on the subcutaneous tissue on the outer side, and towards the axilla. On the outer side of the breast the skin is adherent and thrown in wrinkles. The nipple is markedly retracted, and two tubers can be seen on the skin. The whole mass is firmly adherent to the pectoralis major, but not to the ribs. High up on the inner side of the axilla is an enlarged gland the size of a walnut. There is loss of sensation on the outer side of the arm; one of the supraclavicular glands is slightly enlarged. The pulse is irregular, weak, and intermittent. A presystolic *bruit* can be heard.

Diagnosis: Carcinoma of the breast, also confirmed by Mr. Bryant.

October 4th.—Under ether, interrupted voltaic current, gradually raised to 300 milliampères, was applied to the under part of growth. Any attempt to exceed this strength caused great irregularity of the cardiac beat. After 30 interruptions of the current it was necessary to desist, on account of the weak action of the heart.

October 10th.—Same treatment was repeated to the rest of the growth, with the same limitations as before.

October 25th.—The gland in the axilla was treated, and, as the pulse was not affected, the current was raised to 500 milliampères. The patient went home next day.

November 7th.—Pain in the shoulder and arm have quite disappeared, while sensation in the outer part of the arm, which she had previously lost, has now come back; but on the outer side of the breast, where considerable shrinkage has taken place, she still feels some pain.

December 19th.—Condition unchanged. No pain, no sign of recurrence.

February 1st, 1889.—The last few weeks she has had a return of the old pain. There is some redness and further infiltration of the skin near the nipple, and also some puffiness and œdematous swelling on the inner side of the growth. The mass as a whole is still movable and does not appear larger, except for the puffiness before mentioned. But the swelling in the axilla, where the whole force of the battery was used, remains unchanged, nor is there any return of pain in the shoulder or arm.

February 2nd.—Interrupted voltaic current, slowly raised to 400 milliampères, was applied to the whole of the upper and outer parts of the breast. The patient was then sent home.

Case III.—November 12th, 1888.—E. E., aged 36, married.

Present Condition: In place of the cervix there is a large excavated ulcer, in the shape of a hollow cone, extending for a short distance all round into the vaginal wall. Diagnosis: Cancer, confirmed by Drs. Arthur W. Edis, Travers and Gerald Harper. On consultation, the case is considered beyond operation.

November 18th.—Ether administered. Interrupted voltaic current applied to the growth. Intensity 400 milliampères.

December 10th.—She had no discomfort from the application. Ulcer is harder; still bleeds easily.

Ether administered. Interrupted voltaic current, 600 milliampères, applied to every part of the growth and tissues round. To return home.

March 9th.—After going home she was for some weeks in bed; the hæmorrhage, however, gradually went off, and she has had none for a fortnight. The last occasion she thinks was her period. She now has no trouble with the bladder nor has she lost flesh, and she is able to get about her house and do some work. She still feels some pain in the groins, but it is very much less.

On examination, the uterus is freely movable, and there is no infiltration of the surrounding tissues. The cup-shaped depression formed by the remains of the growth is very hard, but does not bleed at all on being touched.

Case IV.—January 15th, 1889.—M. W., aged 61.

Past History: Two years ago she had a lump taken out of the upper part of the right breast at the Cancer Hospital. It recurred in 12 months' time, and has continued to grow since. She suffered no pain, or very little, from it.

Present Condition: At the upper part of the right breast there is a small, hard, nodular mass, about 2 inches long and 1 inch broad. The skin over it is movable, but not freely so; it is attached to the pectoralis major and surrounding tissues, but it is not adherent to the ribs. There is no enlargement of the axillary or other glands.

January 18th, 1889.—Interrupted voltaic current was applied to the growth, strength 600 milliampères.

January 20th.—Patient has experienced no pain or other ill effect from the current, and can go home.

March 12th.—The growth appears to have shrunk, and she has no pain and no enlarged glands.

April 9th.—Patient continues quite well; no signs of growth recurring.

Remarks.—Case I. Although this patient up to the beginning of March, eight months after the first application, showed no signs of recurrence it is, of course, possible that this may occur, because I did not at that time feel sufficiently sure of my ground to increase the current beyond 400 milliampères. With the second patient, who has heart disease, the quiescent state of the nodule in the axilla ever since it was treated, six months ago, with full force of 600 milliampères, compared with the renewal of activity in the older portion of the growth in the breast, where it was only possible to use 300 milliampères, is very striking, because, as a rule, at this stage of the disease the growth is usually most virulent and active in the secondary formations.

The advanced stage in which Case III. was taken in hand gave very little hope of a successful result. Notwithstanding this, the patient at the end of three months is wonderfully improved, and able to go about and do her work. It seemed more than probable that as the patient was beyond surgical interference there would be some involvement of the lumbar glands which would be most difficult to get at, and, therefore, the possibility of metastatic deposits in this case must not be overlooked.

With regard to Case IV., the small size of the growth and the absence of any enlarged glands, and the capacity of the patient to stand the full force of the current required, give every hope of a successful result.

I feel very little doubt that some patients will be able to stand even a stronger current than 600 milliampères, which is the maximum at present obtained. If recurrence occurs, I should feel no hesitation in increasing the intensity beyond that point. It may be said that cases of scirrhus are only slow growing, but with Cases I. and II. the previous history of so short a time as six months and twelve months respectively shows that, on the contrary, the growth has been remarkably active.—*British Medical Journal.*

ANOTHER PROJECT!

The Engineers' Institute.

The Editor of *Electrical Plant* has kindly forwarded us advance proofs of an article which advocates the formation of an Institute for engineers in general, from which we extract the following:—

An intelligent observer can hardly fail to have noticed that the engineering profession in general—so far from becoming more and more strongly differentiated—has practically lost all those boundaries or divisions which at first cut sharp lines of distinction between one branch and another. There are very few now in our midst who belong to the original class of civil engineer strictly so called—that is, the men who spent their

lives in planning roads, canals, docks or harbours—men of such a stamp as Brindley, Telford, or Brunel. The great modifying influence was felt when railways came into prominent use, and the mechanical engineer—such as Stephenson and his necessary concomitant Whitworth—proved to be as equally important as the civil engineer who helped to map out the iron roads upon which the locomotive should run.

The continual merging of each branch into the other has been still further helped on by the enormous growth of our textile and manufacturing industries—all which has practically led to the same class being consulted with regard both to the mechanical details of the machinery occupying a huge factory, and also the construction of such a building itself.

All types of engineers find it essential to be tolerably well versed in the other branches also of their profession, and on the mere question of quicker and better transit for passengers or goods, it is impossible for anyone to say which of the three has a more important status—the civil, mechanical, or electrical engineer. Distinctions or rivalries between these have vanished, if, indeed, they ever existed.

The Institution of Civil Engineers discusses the the theory of alternating current machines! The Institution of Mechanical Engineers goes into the questions of ship canals and turbo-generators for dynamo driving; whilst the Institute of Electrical Engineers will, doubtless, decide at an early date upon the best method to construct and operate by means of electricity, the London Central Subway.

The fact of all these three learned societies meeting on common ground is sufficiently emphasised by the above instances, and we need say no more on this point. Members of any one will understand and feel the force of this argument, which we now wish to apply to its express purpose in the proposal hinted at in the first place.

We now appeal to the Institute of Electrical Engineers—the institute in which, perhaps, we have most concern—to do its part in bringing about a *rapprochement* between the three institutes which may lead to the erection of a combined institute house and hall for general use.

There should be separate council chambers, committee rooms and suites of offices for each institute; so that although combined and brought under one roof, they may yet preserve their individuality. Above all, there should be one great and all embracing scientific library, where engineers of all grades, sizes, sects or denominations, may study the best works published in each branch of the profession with the least possible waste of time.

Room might be found for meeting places of a social nature, but any attempt at carrying out the idea of a club would, we fear, prove fatal to the true dignity of Engineers' Hall.

Perhaps the most important, however, of all conceivable uses to which the proposed institute might be placed, would be its employment for the purposes of arbitrations or references of disputed points to umpires mutually agreed upon by the opposing parties or individuals. It will be remembered that this was a leading feature in the programme of the electrical trades section in the Chamber of Commerce, and without at all trenching upon the ground that is likely thereby to become very ably covered, the proposed institute would form, in our opinion, the best possible meeting place for such arbitrations or references to be carried out. These—it will be borne in mind—are continually going on as regards one matter after another; and the income derivable from this source alone would prove sufficiently handsome to warrant a fair prospect for, at least, so much of the scheme.

The expense of such a hall or institute as we propose will doubtless be great, but the resultant benefits will also be equally great. The various engineering institutions already in existence are well to do; as a rule their assets are so much in excess of all liabilities, that investments for the surplus have necessarily to be sought. What better investment, we ask, could be made than that we herein propose, of a united institute or hall for engineers in general, where forces may, to some extent, be concentred though not combined, and where engineers may meet in what would, in very sooth, be their national assembly?

AN UNIVERSAL DEAD-BEAT GALVANOMETER.*

By M. D'ARSONVAL.

THE apparatus which I am about to describe has been specially devised for physiological researches. But, in consequence of its arrangement, it can also be used for various kinds of measurements, temperatures, electromotive forces, resistances, capacities, current strengths, ballistic measurements, &c.; in fact, for electrical measurement generally.

This galvanometer is a tangent instrument, of the Wiedemann description, but with numerous modifications, of which practice has successively shown the utility and convenience.

The instrument is dead-beat or ballistic as desired: it can be transformed into a Nobili astatic instrument, into a simple Thomson or into a differential Thomson, by a simple change of the magnetic needle and its attachments. This great elasticity has the advantage of giving a single apparatus of great precision adaptable to all wants (all the pieces which compose it being interchangeable), and of a moderate price.

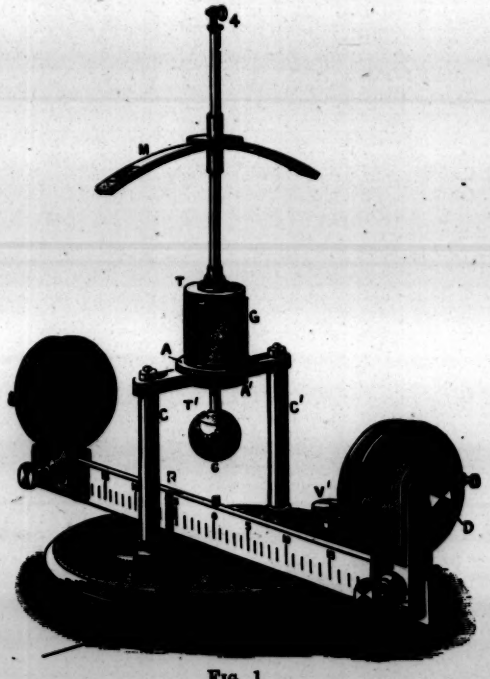


FIG. 1.

An important modification consists in the complete separation of the frame carrying the coils from the part which receives the needle attachments and the damper; the changes, the manipulation, and the carriage of the apparatus are effected with great facility. I will describe the two parts separately.

Fixed Part.—Fig. 1 which represents a perspective view of the galvanometer, and fig. 2 a section of the movable part, are reproduced from *Revue Internationale de L'Electricité*. On a circular plate, P, a divided rule, R, can be clamped. The plate rests on three points, of which two only are adjustable screws, V, V'. The line which joins them is perpendicular to the direction of

* This instrument was described more briefly and without illustrations in the REVIEW for January 18th, at the time it was presented to the French Physical Society.

the rule, R, so that it is sufficient to place the screws, V, V′, in the line of the magnetic meridian for the apparatus to be orientated once for all.

Along the rule can slide two carriers, E, E, provided with screws which enable them to be clamped. The upper parts of the carriers each carry a thumbscrew, D, which serves to fix circular coils, B, B′, through which pass the currents to be measured. The frames of these coils are of wood and are each turned with a hemispherical cavity, in which the damping sphere, 6, fits. Each coil is provided with two terminals, and on the flat surface of the coils is engraved the number of turns and the resistance of the latter.

The renewal of these coils is an extremely easy matter, and costs very little. The coils are respectively of 150 turns of low resistance (·4 ohm), and 15,000 turns of high resistance (20,000 ohms) for ballistic purposes and the measurement of electromotive forces.

On each side of the rule, R, two pillars, C, C′, rise; these pillars are connected at their upper extremities by a cross piece, A′, in which is a circular aperture, in which rests the portion, A, of the apparatus shown in detail in fig. 2.

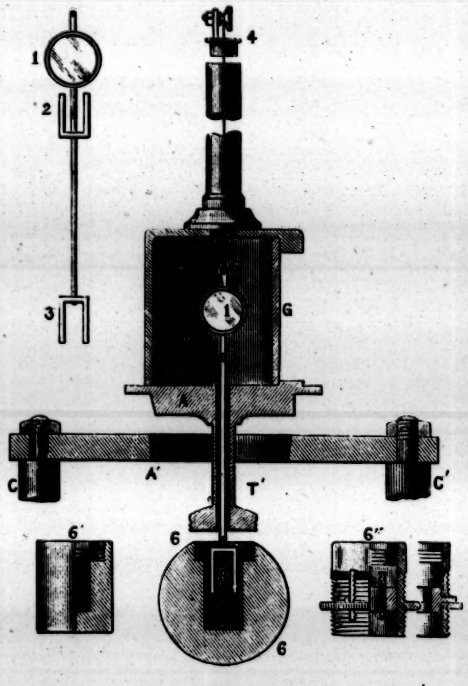


FIG. 2.

Movable Part.—The movable part (the magnet and its fitting, and the damper) consists of a cylindrical box, T, of which the upper part is surmounted by a metallic tube, on the length of which slides the adjusting magnet, M (fig. 1), and which terminates with a thumbscrew, 4, around which is wound the long cocoon fibre which suspends the magnet fitting.

The lower base, A, is chamfered, and fits closely into the aperture in the cross piece, A′. This base terminates by a small tube, T′, at the end of which is a flare, into which screws the copper damper, 6. The box, T, has a square opening in its side, closed by a glass pane, G, which can be taken out when it is required to get at the mirror, 1, and its suspension, 5.

The glass, G, is set slightly oblique, as shown in fig. 2, in order to avoid the reflections which are so annoying to the experimenter when the glass and the mirror are parallel.

The cocoon fibre, whose upper end is fixed to the adjusting screw, 4, is fixed at its other extremity to the mirror, 1, by the eyelet hole, 5. The simple magnetic attachment is formed of a little horseshoe magnet, weighing from 1·5 to 2·0 gr., and is in consequence of its shape very powerful; it can carry a weight 62 times as great as its own weight. It is screwed to a metal wire, to the upper part of which is fixed spring-tight a piece carrying the mirror, 1; this allows the mirror being set in any convenient position. The piece carrying the mirror has fixed at its upper end the suspension eyelet, 5. The damper is formed of a copper sphere, 6, screwed to the flare at the end of T′. It has in it a cylindrical space in which the horseshoe magnet fits with about 1 mm. of space all round. As the sphere has a diameter of 4 cm., whilst the outside diameter of the horseshoe magnet is 1 cm. only, the damping is considerable, even without astaticising the instrument; and, moreover, it remains the same in all azimuths. It can be seen that it is very easy to take off the damper without touching the magnet attachments. A simple sphere of thin brass can be used in the place of the one of solid copper, or a less powerful cylindrical damper, 6′, or, again, an adjustable damper, 6″. The adjustable damper is formed of a ring of copper which can be slid in a split cylinder by means of two pins and an outside filletted ring, as shown by 6″. The magnet can thus be more or less enclosed by the damper, and thus the damping action be gradually altered. A liquid damper can be made by filling the thin sphere with any liquid desired. I prefer for the purpose ordinary paraffin oil.

By using the directing magnet, M, the instrument becomes one of the ordinary tangent type. If it is astaticised on the Hatty principle, the magnet, M, can be set at any required height in the ordinary way. The damping then becomes so considerable that one is obliged to diminish it by replacing the sphere, 6, by either the cylinder, 6′, or the adjustable damper, 6″.

The instrument can also be astaticised by the Nobili method; to do this a second horseshoe magnet, 2, is placed in the stalk carrying the horseshoe magnet, 3, as shown at the upper left-hand corner of fig. 2, the poles of the two magnets opposing each other. As all the parts 1, 2, 3, 4, 5, are separable, this is easily done.

Finally, the magnet attachment can be completely removed and replaced by a single or double Thomson arrangement, a liquid damper, if required, being used, which is very effective in this case. By withdrawing the eyelet of the mirror attachment 1, and withdrawing the plug, 4 (at the top of the upper tube), it is extremely easy to change the cocoon fibre; the thumbscrew, to which the latter is attached, is of small dimensions, so that the adjusting magnet, M, can be withdrawn over it without touching the suspension.

By reason of the numerous applications to which the instrument lends itself I have called it a "Universal dead-beat galvanometer." The various modifications which practice has suggested, and show the necessity of, have been carried out in the workshops of M. de Branville, 25, Rue de la Montagne-Sainté-Geneviève.

A SYNTHETIC STUDY OF DYNAMO MACHINES.

(*Continued from page* 448.)

VI.—ARMATURES IN PRACTICE—(*continued*).

IT will have been observed that the expression for the E.M.F. in machines having the coils laid on the interior of a stationary ring, or on the exterior of a rotating ring or drum, differs from the expression for machines in which the armature ring is enveloped by the coils. The expression for the latter is

$$E_{\text{average}} = \frac{N\,p\,s\,c}{10^8}, \qquad (a)$$

while for the former it is

$$E_{\text{average}} = \frac{2\,N\,p\,s\,c}{10^8} \qquad (b)$$

As regards the type of machine to which the first expression applies, it will be seen that c, the number of convolutions, is equal to the number of active lengths of wire, while in the second expression c is equal to half the number of active wires. When the coil

envelopes the armature core, as in fig. 96, only the portion of wire from a to b, or one length across the field in each convolution, cuts the lines proceeding from the magnets. But when the coils are laid on the armature surface, as shown in figs. 92 and 93, there are for each convolution two lengths of wire across the field, both of which being equally active, contribute to

FIG. 96

the E.M.F. of the machine. If for c, the number of convolutions in each coil, we substitute the number of wires, w, lying on the surface by which the lines of force enter and exit, we have the same expression for both types of machine, and we may write for the average E.M.F. in volts per coil :

$$\text{E average} = \frac{\text{N } p\ s\ w}{10^8} \qquad (c)$$

This expression is not only true for these two types of machine, but it is true for all types, whether they have in their armatures iron cores or not. Take, for example, the Mordey machine, referred to at page 237. Here there are two active lengths of wire crossing the field for each convolution, and since the expression for the E.M.F. we obtained was as (b), if we substitute for c in this equation its value $\frac{w}{2}$, we obtain the expression (c) now given for the volts per coil. For the Siemens and Ferranti machines we also obtained the expression (b), which by substitution becomes (c), as there are also in both these two active lengths of wire for each convolution. The ring and disc machines in which the coils envelope the core have, as already stated, but one active length of wire for each convolution, and we have merely to substitute w for c in (a); while in those machines in which the coils lie on the surface of the armature, the substitution of $\frac{w}{2}$ for c in (b) gives the expression (c).

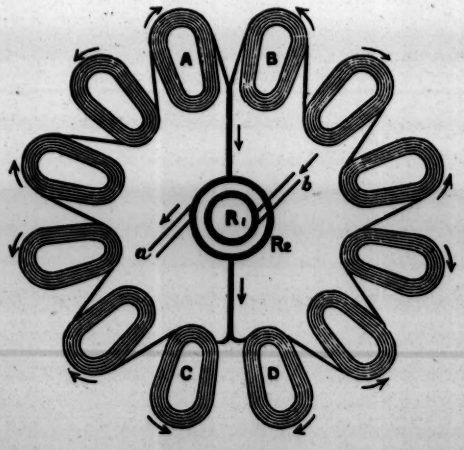


FIG. 97.

The total E.M.F. of a machine is found by multiplying the E.M.F. per coil by the number of coils in series. It is usual to group the armature coils in two parallels at least (fig. 97) in order that the difference of potentials between adjacent coils may not be excessive. Were the coils coupled in series all round, the difference of potentials between the two adjacent ones constituting the first and last would be the full difference of the machine, an average, probably, of 2,500 volts, and a maximum not likely to be less than $2{,}500 \times \frac{\pi}{2}$. But by coupling in the manner shown the difference of potentials between the proximate wires of adjacent coils cannot exceed twice the E.M.F. furnished by each coil in the case of the coreless machines described, or of those in which the coils are laid on the surface of a core, while in the case of the machines in which the core is enveloped by the coils the difference may be very small indeed. To get the total E.M.F. of any machine we have simply to take all the wires, W, which cross the field and which are coupled in series and solve the equation

$$\text{E average} = \frac{\text{N } p\ s\ \text{W } k}{10^8}. \qquad (d)$$

In the case of the Mordey, Siemens and Ferranti machines, W is all the radial wires of the coils connected in series. In the case of machines with iron cores it is the wires which are in series counted all round the surface of the armature, by which the lines of force enter and leave. In the equation, k, is a coefficient to which we have frequently referred as expressing the mean value of all the wires with reference to their activity. The equation (c) assumes that all the wires have maximum activity, and that all add in the same degree to the E.M.F. That they are not with the usual proportions all equally active we have demonstrated at page 381, and a coefficient to express their mean activity will be something less than 1, its value diminishing as the width of the coil is increased. This, as we saw, arises from the fact that some of the wires in the same coil may be acting differentially, or the E.M.Fs. induced in the individual wires may be in opposite directions as regards their coupling.

In last article we compared the length of wire required for the ring armature enveloped by coils, with that required for a disc armature similarly wound. We may now compare, in a few words, the former type of armature with a ring armature, having the coils laid on the surface of the ring. If the number of magnets, and speed, also the respective areas of all the iron parts are similar, there can be exactly the same E.M.F. generated by both machines, there being room on the surface for the same number of active wires. Suppose that fig. 92 (page 447) represents the magnetic part of the machine, the field magnets rotating and the armature being stationary. It is evident at once that when the coils envelope the outside ring, the wire required is much greater for the same E.M.F. than when they are simply laid on the interior surface. If the armature core has a length equal to 5 times its thickness, the proportion shown in fig. 94, we have for every length of active wire, measuring 5 in the former type, a length of inactive wire at the ends and over the exterior surface of the core measuring 7, the total length per convolution being 12. When the coils are laid on the surface only, but a small amount of wire at the ends of the coils is inactive, its mean length being in the present case about 2 for every length of active wire measuring 5. This is clearly shown in fig. 91, where all the straight parts of the coils between a, c, and b, d, are active, the inactive portions being the curved parts between a, b, and c, d. This means that the lengths of conductor on the armatures of these two machines bear to each other the ratio 12 to 7, or machines in which the coils embrace the armature core may have about 70 per cent. more wire than those in which the coils are laid on the surface of the core. Obviously, there is no difference in the amounts of wire required for the magnets. This demonstration is of great interest, for, as we shall see later, the proportions adopted partake frequently of the nature of a compromise between the length of the wire on the armature and the amount of wire on the magnets as determined by the magnetic resistance of the air gaps. But here there is no compromise, the magnetic system is identical in both iron and air parts, and the increase in efficiency is gained solely by a different disposition of the con-

ductors. For the present we are not concerned with any mechanical advantage which one method of winding may possess over the other.

There is very little difference in the machines illustrated in figs. 92 and 93. The former may have a trifling advantage in the fact that the poles of the magnets are where the limbs are farthest apart, while in the latter they are where the limbs are nearest each other. This would cause a rather larger stray field in fig. 93, but the difference is probably very small.

An alternator which has passed from the ken of present-day electricians is that designed by Lontin in 1875. The principle of this machine may be explained by reference to fig. 98. On a brass wheel, A, were

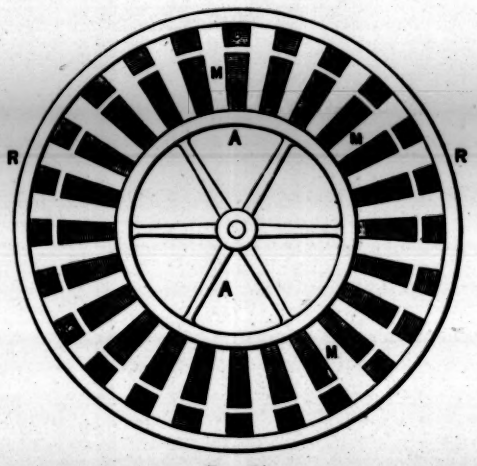


FIG. 98.

mounted 24 flat electro-magnets, M, M, arranged with their poles of N and S polarity alternately. An outside iron ring, R, carried 24 iron cores projecting inwards, on which were wound the armature coils, C, C, an alternating E.M.F. being induced in these coils as the wheel carrying the electro-magnets revolved. The machine is now quite out of date, and would not have been noticed here but for the fact that Messrs. Ganz & Co. have recently constructed large machines of the same type, though vastly improved as regards efficiency and structural details. These machines of Zippernowsky's design have the field magnet wheel built up of U-shaped soft iron sheets, K, fig. 99. Five of these sheets are arranged so as to form a star, to which is added a

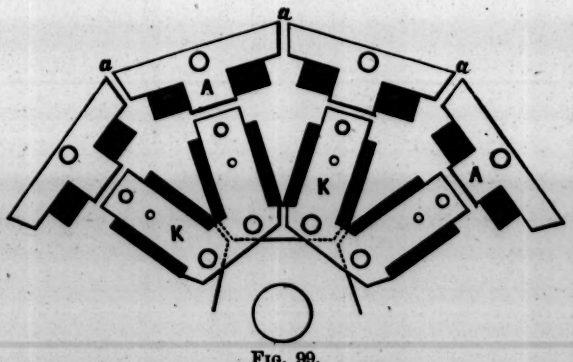


FIG. 99.

similar star, with a sheet of insulating material between, placed in such a way that the joints between the sheets forming the lower star are covered by the sheets of the upper one. In this way many iron sheets are placed one above the other, until the whole electro-magnet wheel is built up. The pile of sheets is then pressed together, properly clamped by bolts, and secured to the driving bosses. In the wheel shown there are ten poles, and the magnetising coils are wound so that they are N and S alternately. The iron plates of which the armature is built up are T-shaped pieces, A, fig. 99. A number of these pieces are clamped together, and each segment so constructed forms, with its armature coil, C, a separate part, which can be inserted or withdrawn without disturbing the rest of the machine. There is some practical advantage in this, though from the fact that there is a small air-gap, *a*, fig. 99, between adjacent segments, a somewhat higher magnetising force is required than if the armature ring were continuous. The machine resembles that shown in fig. 92, but has in addition the radial projections on the armature ring, filling up the inside of the coils with iron. We shall have more to say regarding this machine bye-and-bye, meanwhile we ask our readers to note two important facts concerning it, namely, that it differs from all others in having the field magnets laminated, and that the induction through the magnetic circuit varies with the position of the field magnets.

This article concludes our notice of the armatures employed in machines giving alternating currents. In our next we pass on to consider the armatures belonging to machines of *Class 2.*

(To be continued.)

STORAGE BATTERY PATENTS.

THE Electrical Power Storage Company has handed to us the following copy of a document for publication :—

The President of the United States

TO

The Julien Electric Company, its officers, associates, and its clerks, agents, servants, and workmen, or any of them.

GREETING :—*Whereas* it has been represented to us in our Circuit Court of the United States for the Southern District of New York, in the second circuit, that Letters Patent of the United States were issued to La Societe Anonyme la Force et la Lumiere, of Brussels, Kingdom of Belgium, assignee of Camille A. Faure, dated January 3rd, 1882, No. 252,002, for an improvement in polarisation or secondary batteries, and assigned to the Electrical Accumulator Company ; and that you, the said Julien Electric Company, have infringed the same as to the first claim thereof, as limited by the disclaimer herein filed, upon said letters patent, by the complainant.

Now, therefore, we strictly command and enjoin you, the said The Julien Electric Company, and your officers, associates, and your clerks, agents, servants, and workmen, and each of you, under the penalties that may fall on you and each of you in case of disobedience, that you and each of you forthwith and for ever desist from directly or indirectly making, or causing to be made, using or causing to be used, or vending to others to be used in any manner, any polarisation or secondary batteries, containing or embodying the invention described and claimed in said first claim of said letters patent, as so limited by said disclaimer, to wit : any polarisation or secondary batteries containing or embodying an electrode consisting of a support coated on one or more faces with an active layer of absorptive substance, such as metal or metallic compound, applied thereto in the form of a paint, paste, or cement, and practically insoluble in the electrolytic liquid, so as to be or instantly become spongy, and thus capable of receiving or discharging electricity, as stated in said letters patent, and from vending to others to be used, or using, or causing to be used in any manner, any secondary or polarisation batteries, thus heretofore constructed by you or any of you, and from infringing the first claim of said letters patent, as limited by said disclaimer, in any way whatsoever.

Witness, the Hon. Melville W. Fuller, Chief Justice of the Supreme Court of the United States, of the City of New York, on the twelfth day of April, eighteen hundred and eighty-nine.

(Signed) JOHN A. SHIELDS, *Clerk.*

THE COX-WALKER SWINTON PATENT MAGNETO-ELECTRIC SIGNALS.

THESE magneto-electric generators and bells, devised by Mr. E. Cox-Walker and Mr. A. A. Campbell Swinton, have been introduced to meet the demand for a simple and efficient form of electric signal bell, which shall not require attention of any kind to keep it in working order.

The great disadvantage in connection with ordinary electric signal bells lies in the fact that the battery which up to the present time has always been required to operate them is very troublesome to maintain in effective order, and is apt to fail unexpectedly, thereby causing much annoyance. Moreover, apart from this, batteries are necessarily always consuming, and are, therefore, continually incurring expenditure for replenishment. After some months' working they must be recharged, and in a year or two are worn out, and must be renewed entirely. These operations require skilled labour, often difficult to obtain, and thus lead to considerable expense.

To avoid these difficulties electricians have endeavoured to make use of the well-known principles of the magneto-electric machine, which generates electric currents from the mechanical force required to move a coil of wire in the vicinity of a permanent magnet, without any need for a battery at all; and appliances arranged on this plan have been employed for telegraphic and telephonic purposes.

The Cox-Walker Swinton signal bells operate on similar principles, but are of an entirely novel design which renders large-sized magneto signal bells practicable.

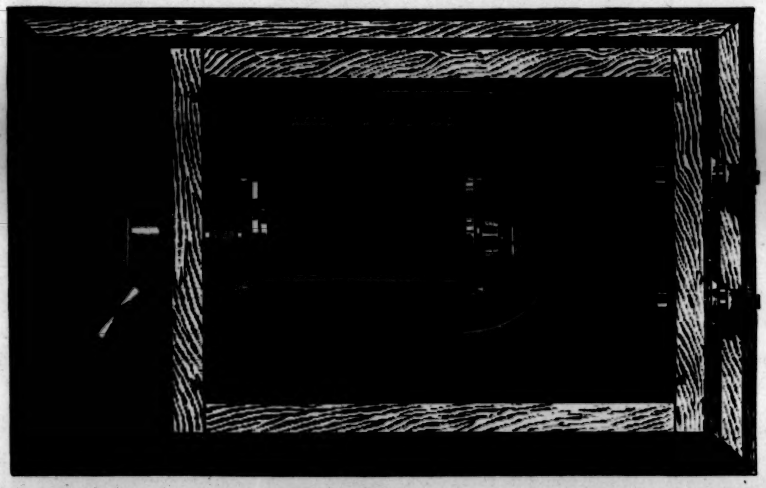


FIG. 1.

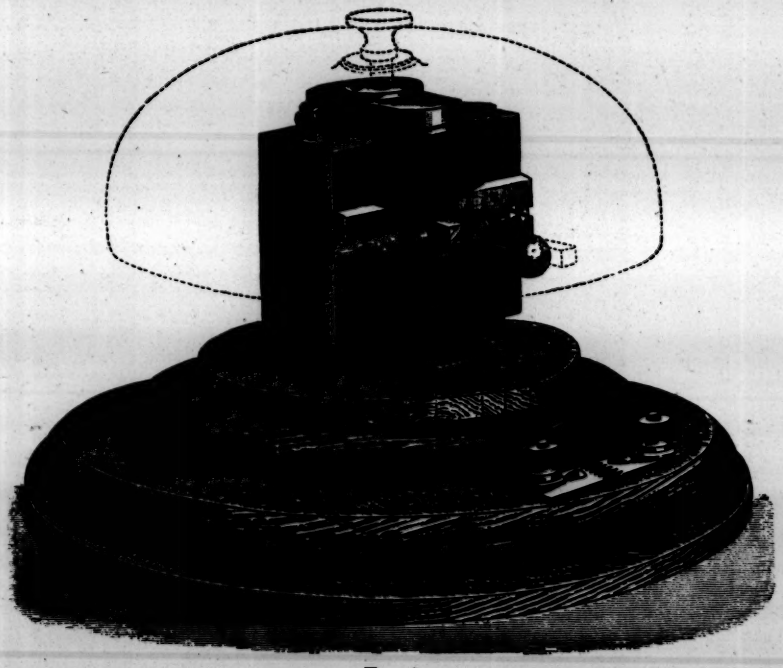


FIG. 2.

The magneto generator, fig. 1, which takes the place of the transmitting key or plunger and the battery used with ordinary electric bells, is of extreme simplicity. It consists of a compound horseshoe permanent steel magnet fitted with soft iron pole pieces, between which is pivoted an armature composed of a soft iron core in the shape of a shuttle wound longitudinally with insulated copper wire. In connection with this armature is the operating mechanism by means of which the armature is easily rotated backwards and forwards through a small arc, this motion generating electric currents in the armature wire by electro-mag-

netic induction, and thus actuating the bell at the other end of the line.

For single stroke bells, such as shown in fig. 2, the operating mechanism consists of a key similar to the usual tapper or push, which is attached to the armature spindle and causes the latter to rotate against a retractive spring under the pressure of the finger. For operating tremulous bells, on the other hand, a small fish-tail-shaped handle is used, which, when taken between the finger and thumb and shaken rapidly to and fro, causes the distant bell to ring continuously.

The mechanism of the bell is similar to that of the generator, with the exception that, instead of the key or handle, the pivoted armature is furnished with a hammer that strikes the gong.

The special advantages of the Cox-Walker Swinton magneto bells are manifest.

REVIEWS.

Practical Plane and Solid Geometry, Scales and Pattern Drawing. Revised and enlarged edition. By J. S. RAWLE, F.S.A., Examiner to the Science and Art Department, South Kensington. London: Simpkin, Marshall & Co., 4, Stationers' Hall Court, E.C.

The favour with which this small book has been received is amply testified by the fact that the present is the 15th edition, and that as many as 140,000 copies of the work have been sold.

Practical geometry has become an important branch of general education, and with the spread of technical instruction it will become more so. Those who wish to gain a thorough practical knowledge of the subject cannot do better than purchase a copy of Mr. Rawle's book.

Electro-Deposition. By ALEXANDER WATT. Third edition, revised, corrected and enlarged. London: Crosby Lockwood & Son, 7, Stationers' Hall Court, E.C.

The chief additions to this well known work are in the form of an appendix. We are pleased to see that the author has eliminated certain doubtful matter, to some of which we drew attention, and has substituted other which is more worthy of the book.

A Pocket-Book of Electrical Rules and Tables for the use of Electricians and Engineers. By JOHN MUNRO and ANDREW JAMIESON. Sixth edition, revised and enlarged.

The rapidity with which edition after edition of this excellent pocket book is brought out continues to testify to the value of the same. In the present edition about 120 pages and 60 new figures have been added, Prof. Silvanus Thompson contributing a new chapter on dynamos and Mr. Gisbert Kapp an article on transformers. A description is also given of Sir William Thomson's latest standard balances, and Profs. Ayrton and Perry's sechommeter.

We think that a certain amount of re-arrangement of the matter would be advisable, as several formulæ, &c., which relate to the same subject are scattered about the book instead of being grouped together. The index also needs revising as it is incorrect and hardly full enough in several places.

LIGHTING THE GARRICK THEATRE.

THE electrical plant for lighting this theatre consists of two vertical marine-type engines, driving two 40-unit shunt-wound Elwell-Parker dynamos.

In addition there are six batteries of accumulators, 31 L type, 40 to each, or a total number of 240 cells, giving a maximum discharge of 360 ampères at 80 volts, sufficient to supply nearly all the lights in the theatre for 12 hours, should engines or dynamos break down.

There are 1,030 lights actually installed, although not above 700 will be in use until more elaborate stage lighting is required for future productions.

The footlights, winglights, and each of the batteries are separately controlled by a switch having six stops, each stop inserting extra resistance, so as to graduate the lights to less than half candle-power.

The special arrangement of the stage fittings makes it easy at any time to reduce or increase the number of lights at a moment's notice, and renders short-circuiting impossible.

The winglights are arranged with plungers fitting into strong sockets, making admirable contact at a moment's notice.

The 100-light electrolier suspended from the dome is arranged in 4 circuits of 25 lights to each, controlled from the stage switchboard with the resistance stop to reduce to ¼ C.P.

The arrangements for lowering this fitting are very complete, taking the man about five minutes. The private box-lights, orchestra, stall-lights, flies, dressing-rooms, and under stage are also controlled from the main switchboard, every circuit being protected by cut-outs on the positive pole, a separate board taking the negative pole.

The board weighs nearly half a ton, and is hinged so as to enable resistances to be altered and connections inspected.

Auditorium.—Smaller switchboards are arranged in pit, dress circle, upper circle, and gallery, to control lights on the various levels, not more than 10 lights being put on each circuit.

General.—A voltmeter is fixed by the prompter's box, within sight of main board, and should any variation occur to necessitate outside attention, the theatre is connected by a private United Telephone Company's line with charging station, the current being supplied from the Whitehall Station of the Metropolitan Electric Supply Company.

NOTES.

The New Town Hall at Portsmouth.—The question of lighting the new Town Hall, which is now in course of erection at Portsmouth at a cost bordering upon £100,000, has already been under the consideration of the committee of the council which is entrusted with the duty of supervising the work. A general opinion appears to prevail among the Corporation that the electric light should be used, and, although no definite decision has yet been arrived at with reference to the matter, little doubt is entertained but that a recommendation in favour of the light of the future would be carried by a large majority.

Shop Lighting.—Messrs. J. P. Smith and Sons, who carry on a very extensive clothier trade in Dundee, have, with commendable enterprise, introduced an installation of the electric light, which illumines the whole of their extensive premises. The new light, which has been in use for a fortnight, is a great improvement on gas, and the lights are very steady. Messrs. Lowdon Brothers, electrical engineers, Tay Street, have carried out the installation.

Lighting the Inner Temple.—We understand that since the abandoning of the elaborate scheme for lighting the Inner Temple it has been decided to extend the existing installation somewhat, and to put down a new 18-unit dynamo. This work has been entrusted to Messrs. Drake and Gorham, who have already executed a considerable amount of work for the Inner Temple in the past.

The Electric Lighting of Chelmsford. — The Chelmsford Town Council has accepted the tender of Messrs. Crompton & Co. to light the public thoroughfares of the borough for five years with 18 arc lamps of 1,000 candle-power each, and 200 incandescent lamps of 32 candle-power each, at a total inclusive cost of £873 6s. 8d. per annum. The Council, however, have granted the company the exclusive privilege of lighting private houses in the borough with electricity during the term covered by the public lighting contract.

Electric Lighting in Spain.—Teruel, the capital of Arragon, is shortly to receive a central station, which will be situated about 1¼ miles from the town. Power is to be supplied from turbines.

Electric Lighting in Switzerland. — The Zurich Municipality has appointed a committee of experts to enquire into the question of the electric lighting of the town. Among the points to be investigated is the probable amount of current required in the different districts of the town, and on this basis to prepare plans.

Harbour Lighting.—The electric light installation for the docks of Bordeaux has been entrusted to Messrs. Buchin, Tricoche & Cie. There will be seven Gramme arc lamps of 30 ampères, and the machine room will be lighted by six incandescent lamps. A steam engine of 30 H.P. will drive two Gramme dynamos of 180 ampères and 70 volts.

The Electric Light in South America.—In a report issued by the Consulate of the Republic of Uruquay, it is stated that in the city of Monte Video electric light works are being erected, which are now very far advanced, and will in a short time supply the public electric light for the whole city. Apparently, South America is rather ahead of London in this matter.

Cables between Europe and the Argentine Republic.—(From the *Elektro-Techniker Journal.*) The journals of Buenos Ayres have been lately discussing the question of establishing a more direct telegraphic communication between the Argentine Republic and Europe. At present messages are exchanged either *viâ* the cables worked by the Western Brazilian and the Brazilian Submarine Companies, or *viâ* the Transandine land lines, and the cables worked by the West Coast of America, the Central and South American, and the Mexican Telegraph Companies, the land lines through the States, and finally the Atlantic cables. Thus, which ever route is followed, the messages have to pass through a great number of stations before arriving in Europe. According to the new scheme there will be only two intermediate stations, one at St. Vincent, and the other at Teneriffe. The distance between Buenos Ayres and St. Vincent is 3,820 knots; between St. Vincent and Teneriffe 900 knots, and between Teneriffe and Lisbon 762 knots, or a total distance of 5,482 nautical miles. In order to allow for the deep water and inequalities of the bottom, a total length of 6,300 knots would be required, representing an outlay of £2,200,000, subdivided as follows :—

6,300 knots of cable at £320 per knot ...	£2,016,000
Laying of cable	32,000
Reserve	24,000
Land lines	16,000
Stations, instruments, &c.	24,000
General expenses, issue of shares, &c. ...	88,000
	£2,200,000

The Telegraph Administration of the Argentine Republic has estimated that the telegrams exchanged with Europe during the year 1888, contained more than a million words.

The Antilles Cables.—The cables belonging to the French Submarine Telegraph Company comprise the following sections :—

	N.M.
Azuadores (Cuba) to Caymanere (Cuba)	50
Caymanera (Cuba) to Mole St. Nicolas (Hayti) ...	126
Mole St. Nicholas (Hayti) to Puerto Plata (St. Domingo)	188
St. Domingo (St. Domingo) to Curaçao	453
Curaçao to La Guayra (Venezuela)	613
Total	980 N.M.

Recent Interruptions and Repairs to Land Lines and Submarine Cables :—

	Interrupted.	Repaired.
Line, Moulmein-Bangkok ...	Feb. 27th ...	March 26th.
Cable, Trinidad-Demerara...	March 20th ...	March 23rd.
Line, Saigon-Bangkok ...	„ 27th ...	April 13th.
Cable, Pernambuco-Bahia...	April 1st ...	„ 20th.
Line, Moulmein-Bangkok ...	„ 16th ...	„ 22nd.
Cable, Santos-Rio de Janeiro	„ 16th ...	„ 25th.
„ Rio Grand do Sul-Monte Video ...	„ 25th ...	Still interrupted.

Proposed Pacific Cable Routes.—The *Dominion Illustrated*, in its issue of April 6th, contains an interesting article on the various routes proposed for a trans-Pacific cable. In discussing the different schemes it is pointed out, and not without some reason, that the Northern, or Mr. Gisborne's route, would be more likely to become the most successful from a commercial point of view, touching, as it does, at Japan, the Phillipine Islands, and New Guinea. This route as proposed, would be :

	N.M.
Sook Bay, British Columbia, to Unimak, Aleutian Island	1,500
Unimak, Aleutian Island, to Attu Island	800
Attu Island to Japan	1,300
Japan to Luzon, Phillipine Islands...	1,200
Luzon, Phillipine Islands, to New Guinea... ...	1,140
New Guinea to Port Darwin, Australia	660
Total distance, nautical miles... ...	6,600

A great advantage in following this route would, of course, be the comparatively short sections as compared with the other routes, thus permitting a higher speed in signalling, but it yet remains to be shown that the bottom on this line is of so favourable nature as that in the more southern routes.

Recent Movements of Cable Ships.—April 13th, *Silvertown* landed shore end at Loanda and left for the southward. April 16th, *Buccaneer* left the Thames bound for Brazilian coast. April 23rd, *Scotia* started laying cable from Port Nolloth towards Mossamedes. April 25th, *Faraday* entered Albert Docks on her return from cable laying in the Gulf of Mexico. April 27th, *Britannia* left Victoria Docks bound for Halifax. April 28th, *Minia* left Victoria Docks bound for Halifax.

West African Cables.—News has been received that the *Silvertown* completed, on the 27th April, that portion of the extension of the West African cables towards the Cape, which the Silvertown Company had contracted to lay. We learn that the final tests gave complete satisfaction. The sections which the *Silvertown* has just completed are those between Mossamedes and Benzuela, and Benzuela to Sao Paulo de Loanda, where connection is made with the cables previously laid by the Silvertown Company, and Mr. M. H. Gray and the staff are to be congratulated on the speedy and successful termination of their work. We understand that the *Silvertown* is now about to undertake some repairs on behalf of the African Direct Company.

The Institution of Electrical Engineers.—The ordinary general meeting will take place at 8 p.m. on Thursday, May 9th, 1889, for a discussion on Dr. Oliver Lodge's paper "Lightning, Lightning Conductors and Lightning Protectors."

City and Guilds of London Institute, Old Students' Association. — An ordinary general meeting will be held at the Technical College, Finsbury, E.C., on Wednesday, May 8th, at 7.45 p.m., when the following paper will be read:—"The Construction and Maintenance of Secondary Batteries," by J. Appleton, member.

Electricity v. Gas.—We last week gave some instances of the strong competition which gas companies were experiencing from the electric light, and a few more cases may now be adduced. The Gas Lighting and Heating Company, Limited, of Corogne and Vigo (Spain), after having lowered its tariff to compete with the electric light, has now made proposals to the Municipality for supplying the electric light itself. The same course was adopted some time ago at Toulon, where the gas company has received powers to erect a central station on a small scale. At Montpellier, the opposition of the Popp Electric Light Company in the second half of the past year caused a diminution of £4,500 in the receipts of the local gas company. The latter has in consequence established a small central station, power being supplied by gas engines, which feeds 230 lamps. This has arrested the progress of the Popp Company, which at present lights the theatre of the town, and, in addition, supplies 350 lamps.

Motive Power for Tramways. — At the ordinary general meeting of the shareholders of the Buenos Ayres and Belgrano Tramways held in London last week, it was stated by the chairman that the working expenses last year were £46,000 as compared with £38,000 in 1887, and £33,000 in 1886. This increase was almost entirely due to the increase in the price of forage, owing to a bad harvest. The enormous effect that such a difference in the annual expenses must have, and the consequent inability to estimate what the profits are likely to be, is another argument in favour of adopting mechanical or electrical systems of propulsion instead of depending upon horses.

Another Yankee Invention. — As a rule the non-technical press is responsible for the stories of marvellous inventions which are completely to revolutionise the existing modes of performing work. The latest thing in this line, however, appears in the *American Engineer* which gravely announces in a specially prominent position, that an engineer of St. Louis, of the common name of Smith, has patented a marvellous machine. It is "a device that when once started manufactures its own electricity, and from the electricity thus manufactured generates the steam that is to keep it in motion." This is evidently meant to oppose the Keeley motor. The expression to "manufacture electricity" is one which is decidedly quaint. Fancy the idea of a section of the "London Directory" devoted to "manufacturers of electricity." Why not also have manufacturers of steam and of hydraulic power?

The Royal Society.—Yesterday the following paper was down for reading:—Prof. J. J. Thomson, F.R.S., "Note on the effect produced by conductors in the neighbourhood of a wire on the rate of propagation of electrical disturbances along it, with a determination of this rate."

Gas in Paris.—The increase in the number of electric light stations in Paris is affecting the consumption of gas. According to *L'Electricien* the official figures published show a consumption of gas during February last of 25,342,868 cubic metres, whereas in February, 1888, the quantity was 26,189,563 cubic metres, being a diminution of 846,695 cubic metres.

The Phonograph Business.—Over 30 sub-companies to carry on the phonograph business have now been formed in America, and their capital stock amounts to about $20,000,000. The parent North American Phonograph Company has orders on hand for thousands of instruments.

The Explosion at Deptford.—An inquest lasting seven hours was held on Saturday, at Greenwich, into the circumstances attending the death of Joseph Selway, aged 37, of 13, Henrietta Street, Deptford, in an explosion at Stowage Wharf, the premises of the London Electric Supply Corporation, on 9th April. While the works were being inspected by Major Marindin, the steam pipe of one of the engines burst. Selway was blown 28 feet by the explosion, and killed, and three other men were seriously injured. Mr. Henry Storey, of the firm of Isaac Storey and Sons, Whalley Range, Manchester, who said that their firm supplied the pipe, had inspected the pipe since the accident, and found one or two defects in the brazing, which the test of 300 lbs. would not discover. It was not customary to rivet as well as braze the flange of this sort of pipe. He thought the bursting was caused by water in the range of pipes. William Inglis, another member of the firm of Hick, Hargreaves & Co., said provision was made for expansion, but there was no expansion joint. Those joints had caused the loss of many lives. The pipe which burst was tested at their works to 300 lbs., and burst at 150. If he had to do the work again he should put the pipes in the same position, and use similar ones to that which burst. He was a man of great experience, and was quite satisfied that the expansion had nothing to do with the explosion, which he thought was due to the faulty brazing. After long deliberation, the jury returned a verdict of accidental death, and added a rider expressing the opinion that the provision for expansion in the cast iron steam main in which the accident occurred was insufficient.

United Telephone Company and Mr. Morgan.—A subscriber to the *Financial News* writes the following pithy letter, under date of April 30th, to that journal: "I think you are rather hard on the managing director, as he is only a Liverpool cotton broker, and knows hardly anything about electricity, and very little about the telephonic requirements of London. Do you not think the real fault lies with the directors trying to put a 'square man into a round hole'? If any concern requires scientific knowledge and discipline in management, it is a telephone business to meet the requirements of this vast population. Then why go to the provinces to secure a cotton broker as managing director? The idea is absurd, and the directors cannot fail to see it. Why did Major Webber, R.E., retire from the position now held by Mr. Morgan? He was the very man for the place with his scientific knowledge, broad views, and well disciplined mind. He is a born commander of man; but Mr. Morgan is the reverse. Had Major Webber remained, no amalgamation would have been necessary, and London would to-day have been talking with all the large towns in the United Kingdom. It was Major Webber's policy to work the whole of the United Kingdom as one company. In addition to the immense boon to the public of having a properly managed telephonic system, fancy the saving to the shareholders—five or six sets of offices, directors, secretaries, engineers, managers, &c., &c., as well as the cost of registering two monster new companies! Again, the well-known electric knowledge of Major Webber would never have allowed lines to be rebuilt with the old dirt-retaining shackles. Mr. Fletcher, the engineer of the United Company, is no doubt a very able man, and would do his work well, only he can hardly move, except on Saturdays and Mondays, when Mr. Morgan is in Liverpool."

Electric Lighting Affecting the Eyes.—In reply to a question, "Does the electric light affect the eyesight?" the journal *Answers* replies as follows:—"Yes, and we have particular reason to know it, inasmuch as one of our editors at one time gave up a lucrative appointment on the *Daily Telegraph* owing to the injury to his eyes caused by the electric light in the editorial rooms of that journal."

The Stockwell Subway.—The Exchange Telegraph Company is informed that the new electrical railway from King William Street, London, to Stockwell, on the south side of the Thames, will be opened for traffic in July or early in August. It is expected that the tunnel will be ready for an experimental trip in about a fortnight. The trains are to follow each other at intervals of three minutes, the cost of the whole journey being 2d. It has not yet been definitely decided as to the precise form of electric motor which will be used for the propulsion of the cars, but it is understood that the directors have several under consideration. Since October, 1886, when the subway was commenced, upwards of 4,000 men have been employed on the work, and so far it has been carried out without any serious hitch or accident. The estimated cost of the undertaking per mile is £230,000, a comparatively small sum when it is considered that the underground railways cost about one million a mile, but this can be accounted for by the fact that the subway company have not been called on to pay anything in the shape of compensation.

Freak of Lightning.—A correspondent, writing from Walnut Street, Cheetham, says: During the brief storm which occurred at noon on Tuesday, the 23rd inst., I witnessed a remarkable incident. A lady friend was at the dinner table, in the act of raising a piece of meat to her mouth with a white metal fork, when the lightning flashed through the apartment and struck the fork, breaking it right in two. At the point of fracture the metal would be at least an eighth of an inch thick. The broken pieces fell on the table, and the lady had a curious numbness in her fingers for two or three minutes afterwards.

Treating Sewage by Electricity.—At the meeting of the London County Council at Guildhall, last Tuesday, Mr. J. G. Rhodes (as the chairman of the committee) brought up the report of the main drainage committee. They reported as follows:—"Your committee has received from the chemist a condensed statement of the course which has been adopted with regard to the deodorisation and the precipitation respectively of the metropolitan sewage, and has directed that copies of the statement shall be lithographed for the use of the committee. The chemist has laid before your committee a letter from Mr. W. Webster, asking, with reference to his experiments at Crossness for treating sewage by electricity, that certain special experiments may be arranged by Mr. Thudichum, one of the chemist's assistants, with Mr. March, the electrician employed by Mr. Webster. Your committee has instructed the chemist to acknowledge Mr. Webster's letter, and inform him than when he is prepared to continue his experiments the chemist will report to your committee, but that it does not give any sanction to the special experiments referred to in his letter."

History of the Transformer.—We have received a copy of a little book, translated from the German of F. Uppenborn, with the above title. We reviewed the original on p. 597 of the REVIEW for November 30th, 1888, and to this we have nothing to add. It is not a little curious, however, that Messrs. E. & F. N. Spon should have been induced to publish the English edition of a work which is decidedly inferior, whether viewed from the historical or scientific standpoint, to that on the same subject by Rankin Kennedy.

Utilising Niagara.—Niagara Falls, according to a local authority, is laughing at Colonel Hamilton, of Topeka, and his water wheel scheme. "I asked him," said a resident, "how he was going to operate his machinery in winter? Nobody goes into the cave of the winds there, and in ordinary winters that whole part of the Falls is a solid mass of ice till May, and when the ice goes it takes with it every bit of the timber, stairs, and the like, that has been put in there the year before. The idea of putting machinery in there is the height of foolishness."—*Buffalo Express.*

Conversazione.—We understand that the President and Lady Thomson are about to issue invitations for a *conversazione* to the Members of the Institution of Electrical Engineers for Friday the 24th May.

Scientific Definitions.—Mr. Preece's rooted antipathy to the "horse-power" is making him quite regardless of accuracy in his definitions of scientific terms. A Mr. Hamilton has caught him tripping on two occasions in the columns of *Engineering*, and another correspondent to that journal asks, with humility, if there is to be a rearrangement of mechanical units in order that the initials of a well-known authority on telegraphy may be immortalised! Thus: 1 kilowatt = 1 watt horse-power = 1 W. H. P.!

The Callender Company.—According to the New York Notes in the *Electrical World* for April 20th, the affairs of the Callender Insulating and Waterproofing Company, which have been in an embarassed condition for some time past, may yet be straightened out to the satisfaction of the American creditors, provided the negotiations for the re-organisation of the company on an American basis are carried through. It is said that the English creditors are willing to waive the enforcement of their claims until the American creditors' claims have been satisfied if the re-organisation can be effected. This news is, of course, anterior in date to the telegram which we reproduced last week from the *Manchester Courier*, as our American contemporary's Notes are dated April 15th.

Birmingham Electrical and Industrial Exhibition.—We hear that a hearty response has been made to the invitations of the committee of management, applications for space having been received from most of the leading firms in the various branches of the electrical industry, and the area allotted to electrical exhibits being fully 25 per cent. of the whole. A large space will be laid out as a garden, and music will also lend its aid in the amusement of the visitors. Several electrical novelties may be expected, amongst those contemplated being a sort of telpherage switchback. In fact, the idea has been taken up so warmly by exhibitors that the management are determined to spar neither trouble nor outlay to ensure the complete success of the show. The Corporation of Birmingham is lending for exhibition what is said to be the first dynamo ever constructed. It is hoped that the exhibition will be ready for opening on the 1st of August.

Brooks's Underground Electrical Conductors.—In a statement which Mr. Brooks has issued with reference to his underground electrical conductor system, he gives the cost of the latter at 21·72 dollars per mile per conductor. Under the heading of Durability we have the following extraordinary statement:—"It takes over 100 times the electromotive force to spark through or disrupt the same thickness of insulation when iron pipe is used instead of lead." We should be glad to have details of the experiments by which Mr. Brooks arrived at this marvellous conclusion.

Presentation to Mr. J. D. Miller.—On Wednesday evening last week, at the conclusion of a course of lectures on technical telephony delivered during the winter by Mr. John D. Miller, district manager of the National Telephone Company, to the male employes of the company, he was presented with a complete edition of the Waverley Novels and with a scientific work of reference, the latter bearing an appropriate inscription. Mr. Miller, in thanking the members of the class, expressed his pleasure in receiving so gratifying evidence of the value of his efforts to extend the technical knowledge of the employes. He thanked them cordially for the valuable present and the kind expressions accompanying it, and hoped the pleasant relations existing between himself and the staff would long continue. The presentation was made by Mr. Brown.

Tramcar Accident. — An Accrington lady named Mrs. Whitlakes died at Blackpool the other day from injuries she received through falling from the top of one of the electric tramcars on the promenade on Saturday last. The unfortunate lady intended to ride outside, and had reached the top of the car. When it was set in motion she overbalanced herself and fell over the rails on to the stone paved roadway, sustaining concussion of the brain.

Obituary.—Robert Stirling Newall.—The following appeared among the obituary notices in the *Times* last Thursday. "The death is announced of Mr. Robert Stirling Newall, D.C.L., F.R.S., F.R.A.S., J.P., of Ferndene, Gateshead, whose name is well known in connection with the invention and manufacture of wire rope. In 1840, Mr. Newall took out a patent for making wire rope; it was this invention that made submarine telegraphy possible. He established works at Gateshead, and his firm manufactured and laid the Dover and Calais cable in 1850, the Holyhead and Howth and Port Patrick in 1252, and the Dover and Ostend, the Firth of Forth, and the Holland cables in 1853. In November, 1854, Mr. Newall suggested a cable from Varna to Balaclava to the Duke of Newcastle, then Minister for War. When this cable was completed, Mr. Newall received the thanks of the Duke of Newcastle. The Black Sea cable was laid by Mr. Newall in 1855, and the Red Sea cable in 1859. After laying the latter, Mr. Newall was wrecked in the *Alma*, when his courage and coolness proved of the greatest help to the shipwrecked passengers. He devoted much of his time to scientific work, and had constructed a 25-inch refracting telescope, which just before his death he offered as a gift to the University of Cambridge. To local matters Mr. Newall devoted much of his time. He was twice Mayor of Gateshead, and he was unanimously asked to be mayor again this year, when the British Association visit Newcastle."

Danger from Alternating Currents.—We cull the following from the New York *Electrical Review*:—"An accident to one of the *employés* of the Fort Wayne Jenney Electric Light Company occurred recently at the company's factory, and, although regrettable in itself, is interesting as showing the exaggerated nature of many of the statements made with regard to the danger of the alternating current. There is no doubt that in this case the man received the full potential of the machine, as he (believing the machine was not running) deliberately seized two brass couplings connecting the machine to the primary of a converter, in multiple with others, and disconnected them from the converter. The result was that he received a severe shock, falling forward, and burning his hands somewhat severely; he did not become unconscious, and after a few seconds succeeded in getting free. Beyond the burns on his hands and the shock to the system he was not much the worse, and expected to be at work again in a day or two. The machine was delivering current at something over 1,000 volts—probably about 1,050.

Tenders Wanted.—For lighting Castle Mona Pavilion, Douglas, Isle of Man, particulars of which may be found in our advertisement columns.

Tenders for lighting the City of London, to be sent in by the 10th inst., are also asked for, particulars of which may be seen in our advertisement columns.

Personal.—Mr. Samuel Elliott, the electrical casing manufacturer of Newbury, has taken London offices at 63, Finsbury Pavement, opposite Moorgate Street Station.

Reconstruction.—It has been found necessary to reconstruct Taylor and Tucker, Limited, in order to facilitate the introduction of additional capital, and in future the business will be carried on by Taylor and Tucker, Art Metal Company, Limited.

New Catalogue.—We have received the fifth edition of the illustrated price list issued by the Electric Apparatus Company, Limited. Anyone desirous of investing in electric bells, and all the paraphernalia connected therewith, galvanometers, frictional machines, telephones, lightning conductors, electro-medical apparatus, electrical gas igniters, and many other useful appliances, should procure a copy of this catalogue.

A New Electric Launch.—Mr. James Adam, boatbuilder, put into the water on Tuesday last week, from his yard at Cardwell Bay, a beautiful new electric launch. She is built from the designs of Mr. G. L. Watson, and is the first of her kind constructed in Gourock, or any other part of Scotland, for a private owner. The dimensions of the launch, which has been named the *Loosestrife*, are as follows:—Length, 50 feet; breadth, 7 feet; depth, 3 feet 7 inches.

Killed by Lightning.—Several deaths from lightning have occurred within the last week or so. Near Leeds a poor woman and her little child were both killed, while her sister, who accompanied her, and who was carrying another infant, escaped in a remarkable manner with but slight injury. Both the deceased were charred in places and generally discoloured, and the clothes of the woman were in places torn to shreds, and the metal framework of the umbrella she carried twisted into fantastic patterns. At the inquest the Coroner stated that the explanation probably was that the deceased alone was carrying an umbrella, the metal tipped point and framework of which would necessarily act as conductors. We hope and believe that the extraordinary experiments of Dr. Lodge, which formed the theme of perhaps the most interesting paper ever read before the Institution of Electrical Engineers, may be the means of minimising the risks from lightning strokes.

Telegraphs in Ecuador.—The lines of the Government have been extended throughout Manabi, and also to connect with the lines of the neighbouring Republic of Colombia and to Garuma and Loja in the South. The charge for local telegrams throughout the Republic has been reduced one half, viz., 20 cents. for the first ten words (address and signature not counting) and ten cents. for each successive ten words.

Heavy Telegrams.—The rapidity which the telegraphic authorities display in dispatching lengthy press messages has long been a source of admiration to those in the habit of making a liberal use of the wires. On the occasion of Lord Salisbury's visit to Bristol last week, 50,000 words were sent to the telegraph office for transmission. Three separate verbatin reports were handed in, in addition to summaries of varying length, and these had to be transmitted to most of the principal towns in the United Kingdom. The bulk of the work was nevertheless got through by midnight.

The Telephone in Germany.—The number of telephone subscribers in Berlin at the close of last year was 9,199, or about 50 per cent. more than in Paris. The total number of places in Germany provided with telephone systems was 174, as against 155 at the end of 1887; there were 189 exchanges as compared with 170 in the previous year, and 38,694 apparatus as compared with 29,247 in 1887.

Telephony in Sweden.—Both Sweden and Norway are remarkable for the progress which has been made in telephonic communication. A line is at present being erected which will connect Stockholm and Gothenburg, or, in other words, the east and west of the Scandinavian Peninsula. Various towns have already inter-urban communication. For instance, Malmo, with 40,000 inhabitants, has 600 subscribers, who can be connected with 30 less important surrounding towns, each with from 10 to 200 subscribers.

The Telephone in Peru.—Acting-Consul Wilson, of Callao, states that a telephone company with British capital has commenced operations between Callao and Lima, and the public are already availing themselves of this means of communication. The business of the company is said to be in a fair way of progressing favourably.

Telephony in Monte Video.—There are two telephone companies in this city. The Uruguaya, late the Gower-Bell, Company has 1,796 subscribers, the average daily communications being 6,000. The Co-operative Telephone Company, although only recently formed, has placed 105 apparatus, and laid out 430 wires, which are not all in working order, owing to the scarcity of apparatus.

NEW COMPANIES REGISTERED.

Jensen Electric Company, Limited.—Capital, £80,000 in £5 shares. Objects: To purchase the business referred to in an agreement of the 26th ult. (not yet filed), between Clifton Shield and C. F. Helder, of the one part, and J. M. McDonnell of the other part, and to acquire and work inventions relating to the production and supply of electricity for light, heat, motive power, and force. Signatories (with 1 share each): J. Proffitt, A. O. Scott, and C. W. Jones, of 32, Great George Street; F. J. Wall, 16, Temperley Road, Balham; V. B. Lambley, 35, Crondace Road, Fulham; J. E. Young, Upper Tooting; Frank Galsworthy, 8, Smith Street, Westminster. The signatories are to nominate the first directors. Qualification for subsequent directors, 100 shares. The remuneration of the board is to be fixed by the company in general meeting. Registered 26th ult. by Batten, Proffitt, and Scott, 32, Great George Street, S.W.

Electric Tramcar Syndicate, Limited.—Capital, £20,000 in £10 shares. Objects: To acquire the British, Belgian, French, and American patents granted to Alfred James Jarman for "Improvements in the construction of electromotors for the propulsion of tramcars, electric locomotives, vehicles, and other purposes." Signatories: *H. G. Hemmerde, 15, Lee Park, Blackheath, 50 shares; J. Hemmerde 50, and A. J. Hemmerde 10 shares, both of 10, Eliot Place, Blackheath; *J. Muirhead, C.E., 23, Regency Street, S.W., 10 shares; *H. J. Archer, 31, Lombard Street, 1 share; Capt. L. La Feuvre, 235, High Road, Lee, 1 share; W. Harris, 136, Drayton Park, N., 1 share. The signatories denoted by an asterisk, and P. E. Lintelhac, of 8, Great Winchester Street, are the first directors. Qualification, £500 of share capital. The company in general meeting will appoint remuneration. The directors may appoint a general manager at a salary not exceeding £300 per annum. Registered 26th ult. by Davidson and Morriss, 40 and 42, Queen Victoria Street.

Schaefer's Patent Etching Company, Limited.—Capital, £10,000 in £1 shares. Objects: To purchase the patent, No. 11,890, dated 17th August, 1888, for improvements in the method of stopping off when etching or metal plating, by galvanic action, granted to Christian Rees Bonne. Signatories (with 1 share each): G. S. Lewis Brown, 38, Southgate Road, N.; H. R. Saxty, 5, Hemmingford Road, N.; A. Ash, Temple Chambers, E.C.; Wm. Chapman, 9, Argyle Square, W.C.; J. W. Wildey, 28, Liverpool Street, King's Cross; H. G. Nutter, Hampton Wick; L. H. Bailey, 39, Alderney Street, S.W. Directors' remuneration, £100 per annum each. Registered 27th ult. by C. Robinson and Co., 4, New Inn, W.C.

Lothammer Gas Manufacturing Company, Limited.—Capital, £60,000 in £1 shares. Objects: To carry on any business in which the application of gas, electricity or other power may be used, and to produce, trade and deal in gas or electrical generators or accumulators, and all kinds of electrical and other appliances. Signatories (with 1 share each): Col. H. J. Murray, 39, Lombard Street; W. Bagot Harte, 2, Metal Exchange Buildings; J. H. Bladon, Sidcup; A. W. Stepski, 166, The Grove, Hammersmith; C. R. Brown, 34, St. John's Church Road, Hackney; S. H. Thorpe, 30, High Road, Chiswick; H. M. Robbins, New Malden, Surrey. The signatories are to appoint the first directors; remuneration £100 per annum each, and in addition a divisible sum of 5 per cent. on the net surplus profits after payment of 10 per cent. per annum dividend, provided that £2,500 per annum be the maximum remuneration. Registered 29th ult. by Whitfield and Richardson, 76, Finsbury Pavement. Registered office, 6, Lombard Court, E.C.

Pontypridd Electric Lighting Company, Limited.—Capital £10,000, in £5 shares. Objects: To generate and supply electricity, light, and power within the urban sanitary districts of Pontypridd and Ystradyfodwg, and any other places. Signatories (with 1 share each): Hy. Hopkins, R. Morris Evans, Wm. Williams, D. R. Evans, D. Cull, W. Merchant, W. H. Morgan, all of Pontypridd, Glamorgan. Registered 30th inst., without articles, by Drake, Driver, and Lever, Limited, of New Bridge Street, E.C., as agents for Morgan and Rhys, solicitors, of Pontypridd. Registered office, 40, Null Street, Pontypridd.

CITY NOTES, REPORTS, MEETINGS, &c.

Indo-European Telegraph Company.

THE twenty-second ordinary general meeting of the Indo-European Telegraph Company, Limited, was held on Monday, April 29th, at Winchester House, Old Broad-street, E.C., Mr. J. Herbert Tritton presiding.

The Chairman moved the adoption of the report and accounts, and the declaration of a dividend to December 31st of 17s. 6d. a share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 20s. per share, making altogether 10 per cent., both free of income-tax.

M. H. Weaver seconded the motion.

The Chairman, before putting the motion, drew attention to some details in the accounts. The company had received £110,327, which was an increase of £6,036 beyond the receipts for 1887. The expenses amounted to £52,393, compared with £48,620 in 1887, showing an increase of £3,772. They had paid for wages £500 more, which was mainly due to the company having for a month transacted the whole of the Indian business. There was also an increase of £250, which was caused by two years' rent appearing for the Warsaw station instead of one. An item which he was sure would meet with the shareholders' approval was a donation of 200 gs. which the board felt themselves free to make to the German Inundation Fund, under the distressing circumstances of the case. There was an additional outlay of £1,608 in the maintenance department, consequent upon the reorganisation, which would not recur, and which would result in lessened expenditure in the future. Turning to the traffic, he had to observe that it was from some points of view slightly discouraging, although, as they would perceive, there was, on the whole, an increase. The one discouraging feature was in the fact that it was Indian traffic pure and simple; it did not bring them in now what they might reasonably have expected. The rate of Indian messages was lower in the year 1886, and they had not benefited; on the contrary, they had suffered from the lowering of rates. The messages had not been increasing as some expected. The increase to which he had referred had been made up out of other than purely Indian messages—that was to say, the Trans-Indian, Australasian, Persian, and South Russian messages. It might be interesting to them to know—though this also was discouraging—that the number of words per message was steadily decreasing. In 1880 it was 18·83; it had gradually decreased until, in 1888, the number of words per message was only 12·66. This must be attributed, he supposed, to the greater proficiency in what was called "coding," whereby very much more was conveyed than the actual number of words would imply. The amount of business was regulated, not so much by the tariff, but depended mainly, if not entirely, upon the activity or sluggishness of trade. Next year there would be a telegraphic conference held in Paris, to which they looked forward with feelings not altogether unmixed with anxiety, as they never knew what might be done at these conferences, and they had large interests to foster and protect.

Mr. Jackson eulogised the manner in which the interests of the company had been attended to by the management, and expressed satisfaction at the result. He thought it must be patent to everybody that the assumption by Government of the telegraphic service as part of the postal service of every country was but a question of time, and probably a short time, and he hoped the directors would see that their rights did not suffer.

The Chairman said the company need have no fear of confiscation, and when any proposition was brought forward they must be reasonable in their demands while looking to being fairly dealt by.

The motion was carried unanimously.

A vote of thanks to the chairman was carried on the motion of Mr. Jackson and the proceedings closed.

The Great Northern Telegraph Company of Copenhagen.

At the general meeting, held at Copenhagen on the 27th April, 1889, the chairman, C. F. Tietgen, Esq., in rendering an account of the working of the company during the year of 1888, first referred to the state of the company's cables, which had not been quite so satisfactory as in the previous year, as the interruptions had been more frequent. In Europe thirteen interruptions, and in the Far East eight had occurred, without, however, affecting the receipts in any sensible degree. The company's cable steamer in Europe, the *H. C. Ørsted*, had been employed for 143 days, including 8 days in the laying of a cable in the Baltic, between Gjedser in Denmark and Warnemünde in Germany, for the joint account of the Danish and German Governments. The repairing steamer in the Far East, the *Store Nordiske*, had been at work for 146 days, out of which 50 days had been for foreign account.

The traffic revenue had exceeded that of the year of 1887 by about £8,000. From this fact the shareholders would no doubt have drawn the inference that the losses anticipated as consequential upon the Chefoo Convention—a subject which was largely referred to in the last report—had not yet been felt. And so it was; because the convention had not yet been ratified by the supreme authorities in Peking.

It would have carried him too far here to enter into details of all the complicated phases through which the question of the company's position in China had passed, a description of which might only prove misleading to the uninitiated. The fact was, however, that the company had as nearly as possible come back to the point of departure of the previous year, viz., that all the parties interested sincerely desired a final solution; and since then it would appear that it had been more a question of form than of any substantial divergencies, which had stopped the way of the ratification. With a little goodwill on all sides—and the company had certainly shown much of this—the affair could no doubt at any time be settled very expeditiously.

Meanwhile the company remained in a state of uncertainty with regard to their future position in China, and considering the retardation which had taken place, and which left the door open to the unforeseen, they had considered it prudent to deal with the surplus revenue as nearly as possible as in the previous year; and, further, to apply a part of that surplus to an increased amortization of the 1881 bonds. This measure would be understood by the shareholders when they considered that 5 per cent. is paid on these bonds. The unredeemed amount of the same being only about £40,000 it would hardly be worth the while or the expense to resort to a conversion.

With regard to the 1883 bonds the company had in this respect no rights before 1898.

The extension of inland Chinese telegraph lines had not progressed much during the past year, but in Corea a land line had at last been constructed, and opened for traffic on the 18th July, 1888, to convey messages from the capital of Seoul to Fusan, which place was connected with Japan by means of one of this company's cables.

The Wheatstone system had been introduced and well organised on the Russian land lines from St. Petersburg to Wladiwostock (the terminal station on the Pacific). The results of the service on these lines had been satisfactory, and no doubt would still improve.

In accordance with the agreements with the Eastern Extension Company, this company had become co-proprietors of four short lengths of cable between the colony of Hong-Kong and the opposite Continent of China at Kowloon. Two of the cables were worked in connecting Hong-Kong with Canton, and the other two served for telephonic purposes between Hong-Kong and Kowloon. The share of this company's contribution towards the cost of these cables had been taken from the reserve. Out of this fund the cost of spare cable, manufactured in London, had also been defrayed, and it could be expected that the charge under this head might in coming years be larger, owing to the increasing danger to which the cables, particularly those in the North Sea, were exposed by the trawl fishing.

The company had carried out its intention of exhibiting on the occasion of the International Scandinavian Exhibition at Copenhagen, and the result had been that not only the first prize had been awarded to them for telegraphic and electrical instruments, but they had also gained a special "honourable mention."

The company had contributed £500 towards the fund raised in London by the Lord Mayor for alleviating the distress of the sufferers by the famine in China.

The proposed resolutions were unanimously passed.

The Brazilian Submarine Telegraph Company, Limited.

The report of the directors of this company for the half-year ended December 31st, 1888, to be submitted to the thirty-first ordinary general meeting of May 8th, states that the revenue for this period amounted to £133,706 15s. 1d., and the working expenses to £33,553 14s. 8d. After providing £12,880 for debenture interest and sinking funds and £1,985 6s. 10d. for income tax, there remains a balance of £95,289 13s. 7d.; to this is added £4,539 3s. 7d. brought forward from June 30th last, making a total of £99,828 17s. 2d. First and second interim dividends amounting to £39,000 have been paid, and £40,000 transferred to the reserve fund, leaving the sum of £20,828 17s. 2d. to be carried to the next account. Of this amount the directors intend distributing £13,000 to the shareholders with, and in addition to, the quarterly dividend payable in June.

In accordance with the provisions for repayment of the first issue of debentures, dated July 31st, 1884, 145 bonds, representing £14,500, were drawn on the 12th inst., for payment at par on July 31st next. This, with the previous drawings, will make a total repayment of £65,500, leaving £84,500 of the first issue of debentures outstanding.

The question of a reduced rate to Brazil has been under the consideration of the board for some time, and it has been decided that reductions should be made in the tariff to Madeira, St. Vincent, and Pernambuco. It is anticipated the alteration will, at the commencement, affect the company's revenue, but that the growth of traffic resulting from the reduced rates will greatly diminish the possible loss.

Under an arrangement with the African Direct, the West African, and the Eastern and South African Telegraph Companies additional traffic will be brought to this company's lines between St. Vincent and Europe by the new cable now being laid to the Cape of Good Hope.

The various sections of the company's line are in good working order.

The West Coast of America Telegraph Company, Limited.

The balance-sheet and revenue account show a gross increase of £65,714 15s. 4d. for the year ending 31st December, 1888, against £57,893 9s. 9d. for the previous year.

After deducting debenture interest and all other charges there remains a nett profit of £30,646 4s. 6d. for the past year, as compared with £23,114 18s. 1d. for the year 1887. Adding the amount of £333 19s. 3d. brought forward, makes a total of £30,980 3s. 9d. Out of this the following dividends have been paid:—In July, 1888, 4s. per share, £6,000; in January, 1889, 6s. per share, £9,000.

The directors now recommend a further distribution of 2s. per share, payable the 16th inst., making 6 per cent. for the year, to write off £500 from the value of the repairing steamer *Retriever*, thereby reducing her valuation in the books of the company to £17,000, and to add £12,000 to the reserve fund, making the latter £39,000, which distribution will leave £480 3s. 9d. to be carried forward.

The earnings of the company have been materially increased by a satisfactory state of business in the countries served by its lines.

In the month of December the directors purchased an existing land line between Valparaiso and Santiago, which by improved working is already giving good returns on the outlay of capital involved. They have also made arrangements for direct communication between Iquique and Pisagua, a port of increasing importance, by means of a land line. The cables and repairing steamer are kept in perfect working order.

The directors regret to have to report the loss of an esteemed colleague through the death of Mr. Thomas Fielden Campbell. They have filled the vacancy by electing Mr. Frederick Walters to a seat on the Board.

The members of the Board retiring by rotation are Mr. Alfred Marshall and Mr. Frederick Walters; both being eligible, offer themselves for re-election.

The auditor, Mr. J. Weise, of Messrs. Turquand, Youngs & Co., retires, and is eligible for re-election.

The Great Northern Telegraph Company.—Five shillings per £10 share, representing the final dividend for 1888, are now payable at the company's bankers, Messrs. C. I. Hambro and Son, No. 70, Old Broad Street, London, E.C., against coupon No. 15.

The Anglo-American Brush Electric Light Corporation, Limited.—This corporation asks subscriptions for £75,000 six per cent. first mortgage debentures at par. The bonds are secured on the property of the corporation and on its uncalled share capital.

TRAFFIC RECEIPTS.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 30th April are £3,410, as compared with £3,337 in the corresponding period of 1888.

LEGAL.

Rival Medical Electricians.—At the Manchester City Police Court, last week, before the Stipendiary magistrate, Mr. F. J. Headlam, Robert John Parkes, medical electrician, of 2, Church Street, Southport, was charged, on a summons, with having sent a letter to Mr. Ed. Moross, medical electrician, of 342, Oxford Road, Manchester, and 20, Park Street, Grosvenor Square, London, demanding £250 with menaces and threats.—Mr. C. P. M'Keand, instructed by Mr. W. S. Nadin, appeared for the complainant; and Mr. T. Swift, of Liverpool, instructed by Mr. J. Alleyne-Brown, of Southport, appeared for the defendant.

Mr. M'KEAND said that Mr. Moross was a medical electrician, carrying on his business at 342, Oxford Road, Manchester, and the defendant was also a medical electrician, carrying on his business at Southport. It appeared there had been some professional jealousy on the part of the defendant of and concerning Mr. Moross, and Mr. Moross brought an action against Mr. Parkes for a libel contained in the *Manchester Courier* a short time ago. The action was discontinued, and shortly afterwards Mr. Moross, who had been subjected to great annoyance by Mr. Parkes, received a letter from him, which he would read to the court:—

"The Electropathic Establishment,
Church Street, Southport.

"Aaron Geismar, alias Isaac Geismar, alias Dr. Gusmado, alias Professor Albert Le Grand, alias Professor Ernest de Blanc, alias Dr. Edward Moross.

"Your game is up. I know every incident of your history for 15 years, and am acquainted with all your nefarious practices and crime up to-day. You will find that I have not had three months' correspondence with the United States and different parts of the world for nothing. I have in my possession such evidence as would put you in the hands of the police for the rest of your days. Go not to London. A hundred people are watching for you there. Now, I have been put to considerable expense, and I mean to be repaid. If you pay the bearer within 15 minutes after presentation the sum of £250 in cash I will allow you to leave the country (if you do so in 12 hours) in safety. If you do not comply your safety will not be worth a straw in half an hour. The bearer is ignorant of the contents of this letter, and will simply obey instructions. I give you my word of honour that you shall have 12 clear hours to get out of the country on the payment of the sum mentioned herein. ROBT. J. PARKES."

That was a letter of which Mr. Moross very properly complained. On the receipt of that letter from Mr. Parkes by a messenger, a man of the name of Leaf, Mr. Moross, with an amount of astuteness, asked the messenger to wait a few minutes in another room, and then sent for his solicitor. The solicitor came, and gave Mr. Moross the advice that he should not pay any money at all, but that he should take proceedings at once. Those proceedings had been taken, and the case was now before the court. He (Mr. M'Keand) only regretted that a gentleman in Mr. Parkes's position should have thought fit to conduct himself in this manner towards Mr. Moross. Mr. Moross was not at all wishful to be vindictive in the matter. He merely wished to be allowed to conduct his business, which was a business that he was entitled to carry on if he chose, without any interference on the part of Mr. Parkes, and so long as he did that with safety in the future that was all he desired.

Mr. SWIFT said that he should not be prepared to go on with the case that day. Mr. Parkes placed himself in his hands the previous evening. He handed to him (Mr. Swift) what he had referred to as evidence, and he (Mr. Swift) took the opportunity of reading that so-called evidence, and had advised Mr. Parkes that there was no evidence whatever to justify him in writing any such letter as that which he was charged with writing. Under the circumstances, and feeling that he had done, in writing such a letter, an improper thing, he had placed himself unreservedly in his hands, and, therefore, on Mr. Parkes's behalf, he was prepared at once to withdraw, and he did absolutely withdraw, every imputation that Mr. Parkes had made in the letter, or in any other way, upon Mr. Moross, and he consented at once that his worship should make an order upon Mr. Parkes to enter into his recognisances in such sum as the magistrate might think right—subject to the magistrate's better judgment, he would say in the sum of £200—that he should keep the peace and be of good behaviour towards all her Majesty's subjects, and especially towards Mr. Moross, for the next 12 months, and that the order should involve the payment of costs and all reasonable professional allowances. He thought, if that course were acceded to by his friends, as he trusted it would, that the ends of justice would be fully met. Mr. Parkes was a gentleman well known in Southport, and very much respected there. He had carried on business there as a medical electrician for many years, and was established there as a practitioner. He had a household, with a wife and family. It seemed that, being a man much respected in his profession, he was a member of a committee of gentlemen who took upon themselves to inquire into the professions of strangers who came and set up in opposition to them and in rivalry with them, and it was in that way that he had come into collision with Mr. Moross, through investigations which he had been led to make since Mr. Moross recently came among them. He (Mr. Swift) on behalf of Mr. Parkes, absolutely withdrew every imputation. They had no evidence that justified the imputations, and he submitted to the recognisances which the magistrate should order, and over and beyond that, that there might not possibly be any misgiving for the future, he undertook on Mr. Parkes's behalf that he would not either directly or indirectly interfere with Mr. Moross in any way whatever. For the future they should be to one another as if they were inhabitants of different planets. (Laughter.) He did not think he could make the case plainer than that.

Mr. M'KEAND said that, after the very candid explanation and withdrawal of his friend, he would certainly advise Mr. Moross to fall in with that course. He did not know whether the complainant and defendant could be removed to the separate planets that had been alluded to. (Laughter.)

Defendant was then ordered to enter into his own recognisances of £200 to keep the peace towards Mr. Moross for 12 months, and to pay £10 fine and costs.

ELECTRIC LIGHT PROVISIONAL ORDERS.

BOARD OF TRADE INQUIRY.

(*Continued from page 479.*)

THE proceedings on Thursday, the 25th April, before Major MARINDIN, began with the continuation by Mr. H. CRIPPS of his address for the Strand District Board of Works. He stated that by the agreement which had been come to with the Metropolitan Electric Lighting Company, the District Board had secured the following very substantial advantages: First, the definite appropriation of the five stations as a source of light for the district; second, a definite location of distributing mains throughout the entire district in a position satisfactory to the local authority; third, the security that from those stations and mains an adequate supply of electricity would be produced for the district; fourth, an easy means of detecting the cause of any failure or deficiency in the supply of the district; five, an easy means of access to headquarters situated in the district to lodge complaints and obtain remedies; six, definite arrangements for preventing obstruction in the streets; seven, the relief of the Board of Trade from the task of arbitrating between the local authority and the company in regard to works in the streets; eight, freedom of the consumer from the various onerous conditions with regard to his obtaining a supply and arbitrary powers contained in the provisional orders, and nine, a system which augured, as far as possible, for a harmonious working between the local authority and the company. He believed the agreement was of considerable importance to the consumer, especially with regard to a proposed arrangement for a periodical revision of the price to be charged for the light. Having spoken at some length as to the relative merits of the London Electric Supply Corporation and the Metropolitan Electric Lighting Company, Mr. Cripps said that the balance of advantage was with the latter company with which the District Board had entered into an agreement. With regard to the price to be charged for the light there would be the best possible security by means of a periodical revision. As to the question of the rigidity of mains there was nothing to show the practicability of carrying out the system of a long rigid main laid down so as to consist of lengths of solid copper bolted or jointed together. No one really at present knew anything about that, and it presented a difficulty which it seemed was not likely to be overcome by any suggestion made during the inquiry. If the main was to consist of 7 miles of pipes with copper inductors about 21 feet each, it seemed to follow that there must be something like 1,760 joints in the main. The expansive and contracting power of copper was well known and he should not like to say what would be the effect of the expansion or contraction upon the mains so constructed.

Mr. PEMBER: Are you speaking of the distributing mains, or the trunk mains?

Mr. CRIPPS: I am speaking of some of the trunk mains, which Lord Crawford showed here. Mr. Cripps concluded by asking that the Board of Trade should grant the provisional order to the Company which the Board here presented had made an arrangement to withhold assent from the other companies.

Mr. T. COLE was called and examined by Mr. Cripps, stating that he was a member of the Strand District Board of Works, and a member also of a special committee appointed to consider the question of lighting the district by electricity. He was cognisant of all that had taken place with regard to the subject of electricity in the Strand. The witness generally corroborated the statements of the learned counsel.

In the course of cross-examination Mr. Cole said he had only studied the question so far as it affected the Strand. He had not looked at the subject of the supply of electric current for motive power as the committee were only appointed to consider the question of lighting the district. The Committee set aside the Electrical Power Storage Company as one of those which did not satisfy the requirements of the Committee, and they did not wish to have five or six companies pulling up the streets. The Committee had never entered into any negotiations with the Metropolitan Company to supply motive power as well as gas, because they had only to deal with light. They did not go into any technical matters at all, and he did not know anything of the use of the electrical current for motive power because he was not an electrician. What the Committee had learnt about the storage system was rather against it, and it did not meet with their approval,

Mr. HUNTER: Am I to understand that the only reason why you rejected the Electrical Storage Company was because the name of the company indicated its particular system?—Yes.

Witness continued that they had no desire to override the Board of Trade, but rather wished the Board would join with them in securing the advantages which the Strand District Board thought they had secured for their customers by their agreement with the Metropolitan Company.

Mr. W. YOUNG, as representing the Wandsworth District Board, said he appeared as objecting to the Provisional Order of the Metropolitan Company. He urged that the Board of Trade should insist upon the insertion of a clause providing for further capital being raised, as, of the capital of £500,000, £350,000 was already committed, and he thought the remaining £150,000 was not sufficient to adequately deal with the large area of Wandsworth, comprising over 60 miles of streets. As to the generating stations, he said the local authority ought to have a veto. That was a large order to ask for, but generating stations might be a great nuisance to the neighbourhood and depreciate the values of property near to which they were placed. The agreement obtained by the Strand District Board practically acknowledged the right of a veto, for they had agreed upon the two sites for generating stations. If the company would agree to place their stations in certain areas the District Board did not wish to fix them to a particular street; but there should be a limited area, and the local authority should be empowered to say where that area should be. He then alluded to the obstruction and inconvenience likely to be caused by the opening of the streets, and contended that the local authority should have longer notice with respect to such works than was provided for in the Provisional Order. On the question of testing stations he also asked that additional provision should be made in the interest of the local authority, and said that the companies themselves should bear the costs of those stations; but certainly if the local authorities were to bear the cost they should be the parties to decide where the testing stations were to be erected. There should also be a penalty upon the company if they did not give efficient supply, and that penalty ought to go to the local authority, as they would have to incur the expense of prosecuting the companies if necessary. Another important altercation he said was as to the charges, and his board asked for a clause for a sliding scale of charges to be inserted in the order. That principle had already been recognised. Whether such a scale should come into operation now or not he would not say, but certainly after a period of seven years there should be a revision in the prices to be charged. The principle he suggested as to the sliding scale should be similar to that adopted by the gas companies, whereby they reduced the cost to the consumer whenever they paid a dividend over a certain amount.

Mr. ARTHUR SOUTHAM, surveyor for Clapham, gave evidence in support of Mr. Young's statement, and said he considered it important that testing stations should be provided in the district wherever the Board thought it right. The power of choosing the sites for the stations should rest with the local authority, because there was a great deal of good property about the value of which might be otherwise very much depreciated.

In answer to Mr. CRIPPS the Witness said he thought that was a matter which should be dealt with by the Board of Trade.

Mr. WILKIN, who then opened the case on behalf of the St. James's Vestry, said that already that body had consented to two or three orders and licenses, but up to the present year not one of them had actually come into operation, and in fact the supply of electricity under the statute did not commence until the present inquiry was opened. The Vestry had always insisted upon certain primary conditions which they believed would be to the advantage of the public service and to the consumers and shareholders, and in thus to some extent checking the advances of the electric lighting companies in their early stages they had done good service to the public. There was a great deal of large property in the area of St. James's, and therefore it might be expected there would be much consumption of the current, but they had other kinds of property for which the supply of electricity for lighting purposes would be very little with the present prohibitive prices. That district was dotted about with small manufactories which would require motive power, and they would be glad to see electricity introduced into that portion of the parish for the purposes of power. He stated that the early history of the gas companies served to illustrate the fact that there was a great and wasteful expenditure of money, entirely due to the mistaken policy of free trade in gas then adopted. It might be said that the circumstances of the electric lighting companies were somewhat different to the condition of the gas companies when districting took place, but he was not at all sure that those differences, if any, were worth considering. What his vestry contended was that they had not yet arrived at the stage at which they could say that a certain company was the best to which to hand over any district. As far back as 1882, when the electric light Bill was introduced, scientific experts said that electric lighting had passed from the theoretical into the practical stage; but that was scarcely so, as would be seen if they compared the dynamos used in the early history of electric lighting, and those at present in use. The whole system of the London Electric Supply Corporation was experimental. They were to have dynamos larger than ever before admitted; they were to use a rigid concentric main which would be jointed at every 20 yards, and it was thus admitted that at every twenty yards there would be a weakest point in the system; and, in addition, they had a potential of 10,000 volts, which had never yet been attempted except on a small scale. But here the attempt was to be extended over seven miles. And then they were to have generating stations which were also to some extent an experiment. The question arose whether it was wise to entrust the company with so large an area in which to make so gigantic an experiment. Mr. Wilkin then said that the Vestry had adopted two companies—the one company using the continuous current low tension and the other the high tension alternating system—so that there was a competition in the current as well as in the management. They had taken a middle course because the time had not arrived yet for a system of districting to be adopted. With reference to the subject of overhead wires, he said they were very objectionable, and, besides that, it was not certain that they could be legally carried out without consent being obtained. The first objection they had to the system of the London Electric Supply Corporation was that the system was not sufficiently applicable for the purposes required; and, as to the potention to be used of 10,000 volts, it was something worse than bottling lightning. Then there was the objection of many joints and long currents, and the long distance. As to insulation also, they had not been satisfied that proper precautions had been taken for an effective insulation of the enormous potential. No doubt, insulation would be proposed in the course of time for almost any electrical potention, but at present it was a matter of some doubt. There were several electrical problems which had not been satisfactorily solved, such as the consequence of leakage to earth; the interference with other systems, and the varying tensions. Another objection was that the company proposed to take and supply a large area, moment by moment, with electricity from their stations, using it to the fullest extent, so that if there was any breakdown there was no reserve to fall back upon. He then said that the comparison of the station out of London, at Deptford, with the gas company's stations at Becton and Fulham were not at all analagous. He further took exception to the suggested economies which it was said could be effected by having such a station. He differed altogether from Lord Crawford, who said that a company had a common law right as to overhead wires; but he (Mr. Wilkin) said there was no such right if there was a likelihood of injury to the public. The distributing boxes should also, he said, be subjected to the consent of the local authority, especially in St. James's, where the space was so limited.

Mr. JAMES SWINBURNE was then called by Mr. Wilkin, and examined in support of the case of the St. James's Vestry, especially in regard to the suggested economies which the London Electric Supply Corporation said would be effected by having one large central station at Deptford.

Mr. HITCHINGS briefly, and late in the afternoon, opened the case for the Vestry of St. George's, Hanover Square. He said the vestry had negotiated with three companies out of the four which proposed to light the district. These were the Metropolitan Company, the London Corporation, and the Westminster and Chelsea Companies. As regarded the London Corporation, the vestry had been negotiating with them in reference to the form of the Provisional Order, and had sent in certain objections to the Board of Trade, which the corporation had agreed to. With regard to the Metropolitan Company, they had also delivered requisitions with certain suggestions and amendments, which that company had also agreed to adopt. As to the Westminster Company, the vestry were quite willing that that should come into the district, and the company had agreed to the objections sent them. The Chelsea Company proposed to take a certain small proportion of the parish, and, as the vestry considered, a picked district, and inasmuch as there were already three companies in the district, it was considered undesirable that a fourth should be allowed in.

At this point, after a long sitting, the enquiry was adjourned.

On resuming on Friday morning the enquiry before Major MARINDIN,

Mr. HITCHINGS, in continuing the case for the St. George's, Hanover Square, called Mr. SMITH, Vestry Clerk to St. George's, who said his Vestry had taken considerable interest in electric lighting, and had an electrical committee; the chairman was Lord Hobhouse. There were four companies making application for Provisional Orders—the London Electric Supply Corporation, the Metropolitan Electrical Supply Company, Limited, Westminster Electrical Lighting Company, and the Chelsea Company. These orders had been carefully considered by the Electric Lighting Committee and the Vestry. In January last the committee made a report to the Vestry upon the different orders. Omitting the question of the Chelsea Company, the objections raised to the London orders were, that the time for compulsory works was too long, and the Vestry proposed that it should be reduced to 18 months; there was the objection as to overhead wires; the Vestry required that a proviso might be inserted in the order that no overhead wires should be placed without the express sanction of the local authority. The next point was the question of penalty. The Vestry thought that a money penalty was desirable of £5 per day if the company failed to supply the light after being desired to do so. There were various other questions which were not of vital importance. The Chelsea Company had been objected to from the first, one of the grounds for objection being that they only proposed to take a smaller portion of the parish. The Vestry would encourage electric lighting in the parish, and were also in favour of competition so far as it would be beneficial to the consumers. At the same time they considered that three companies would be quite as many as should be allowed, on the grounds that more would interfere with the street mains.

Mr. HEWITT, on behalf of the Kensington Local Board, then gave the objections.

Mr. H. L. CRIPPS, representing the Marylebone District Local Board, said it appeared to them very undesirable that the application of the London Electric Supply Company should be granted. In the first place the position of the company with regard to the sytem was rather peculiar, because Marylebone would be, under the present scheme, upon the extreme outskirts of the area of supply, and after the evidence which had been given as to the possibility of a scheme of the London Electric Supply Company supplying Marylebone, which would be served from Deptford, he considered it might be one of considerable disadvantage. He would ask the inspector, on behalf of the Vestry of Marylebone, to recommend the Provisional Orders applied for by the Metropolitan Electric Light Company.

Mr. W. E. GREENWELL, clerk to the Vestry of Marylebone, then gave evidence.

Mr. H. L. CRIPPS then gave the case of the St. Margaret and St. John's, Westminster, and the considering of the views of the inhabitants, thought it would be better if the Board of Trade did not interfere in the matter.

Mr. JONES addressed the inspector on the part of the St. Giles District Board of Works, and said that authority was sincerely desirous for the introduction of the electric light into that district. After considering the proposals of the London and the Metropolitan Companies, they decided to consent to both applying for provisional orders, reserving the right to bring objections before the notice of the Board of Trade.

Mr. SMITH, speaking on behalf of the Lambeth Vestry, said they considered the companies should accept responsibilities as well as gain advantages. They were disposed to favour the applications of the London and the Metropolitan Companies, if they would agree to accept a compulsory area which should be lighted. The vestry also insisted that the companies should lay all distributing mains at their own expense.

Mr. COATES, on behalf of the St. Pancras Vestry, said they proposed to undertake the supply themselves, and asked that no company should be allowed to compete with them. They thought that if any profit was to be made the ratepayers ought to have the benefit of it, and they considered also that they would be in a better position to make a profit than any company.

In answer to the inspector, Mr. COATES said that undoubtedly it was the *bona fide* intention of the vestry to put the Act into operation in some form or other. The vestry had already obtained an order conferring powers on them.

Mr. MOULTON, on behalf of the telephone companies, urged that a clause should be inserted in the orders granted necessitating such a construction of the works and mains as would prevent any interference, by induction or otherwise, with electric circuits used for telephonic and telegraphic purposes.

Mr. RUSSELL GRIFFITHS, on the part of the Commissioners of Sewers, said that after hearing the evidence he could not see that any powers should be granted to either the London or the Metropolitan Companies for electric lighting in the City.

Mr. WALLACE having addressed the inspector for the Kensington and Knightsbridge Company, the inquiry was adjourned.

The enquiry was resumed on Saturday at the Westminster Town Hall. The enquiry has now been in progress for a month, and the stage reached on Saturday was that in which the counsel appearing for the several companies addressed the representative of the Board of Trade. Mr. Pember, Q.C., who represents the London Electric Light Corporation, is to speak last.

Mr. WALLACE opened the proceedings on Saturday by speaking on behalf of the Kensington and Knightsbridge Company (one of several West End companies he represents), and replied to the objections raised to that company's receiving the powers to light the limited district defined by its name—a district including the detached portion of St. Margaret's parish on the western side of St. George's, Hanover Square. He declared that the balance of evidence of experts was that the system of this company (the direct) was the best suited to a district, and was more advantageous than that of the Chelsea Company, which was a rival candidate for powers to light the same district in whole or part. Moreover, he urged, the Kensington and Knightsbridge Company were ready to light the district, and this the Chelsea Company had acknowledged it was not ready to do. He then dealt with the House-to-House Company's proposals, and insisted that the company which he represented had made out its claim to the part of the district in Kensington which the House-to-House Company had scheduled.

Major MARINDIN, referring to a part of the royal property in Kensington, enquired if the company asked for an order to light this property.

Mr. WALLACE replied that the company had included this part in its application; but it was to be questioned whether the power of the Board of Trade would extend to this property, and the company did not therefore press this claim. But, he added, the company had the licence of the Commissioners of Woods and Forests to light the western portion of the Royal property. He proceeded then to address the court on the part of the Notting Hill Electric Light Company, which proposed to light the northern part of the Kensington district, and stated that it was a company formed by gentlemen resident in the district.

Mr. PEMBER said that the court had not seen the list of the shareholders of this company.

Mr. WALLACE said he objected to supply Mr. Pember with the list of shareholders, but the list of subscribers would be handed to the Board of Trade, whose officers could be assured of the *bona fides* of the company.

Mr. SHIRESS WILL, Q.C., then addressed the court on behalf of the House-to-House Company. He acknowledged the fairness with which the objections of the local authorities had been presented, and then dealt with the attacks which had been made by rival companies on the district in Kensington allotted by the local authorities to the House-to-House Company, and he maintained that no reason had been shown why this allotted district should not be kept intact. He insisted that no reason had been shown in the evidence why the Chelsea Company and the Kensington and Knightsbridge Company should encroach on the district assigned to the House-to-House Company. As to the objection of the local authorities to overhead wires, his company had no intention of having overhead wires, and would concede the principle that no overhead wires should be placed without the consent of the local authorities. His company thought that if subways were made by the parishes it would not be fair to expect the companies to pay such a rent for their mains in the subways as the local authorities should fix. He objected also to the proposal of the local authorities that they should not be responsible for damage to the mains, when laid in the streets, by reason of negligent usage of steam rollers or other heavy traffic. This clause should be modified. In reference to the system of the company he urged that the alternating system of the company had distinct advantages in permitting an undertaking to go far and wide, while the direct was only applicable to a compact district. The House-to-House Company would consent to be purchased after 21 years; but they asked that this should be by arbitration.

Mr. PEMBER asked if the company represented by Mr. Shiress Will was making any application for the lighting of St. Martin's-in-the-Fields, as Mr. S. Will had not referred to that district in his speech.

Mr. S. WILL replied that such an application was not now before the Board of Trade, but that the company hoped in the future to make such an application.

Mr. WALLACE then spoke on behalf of the Westminster Electric Lighting Company, and justified the action of that company, which was in a similar position to the Notting Hill Company, in not raising capital before getting an order, as wise and prudent, and questioned the wisdom of the London Electric Light Corporation in laying down a large plant at Deptford before they had proved what they could do. Although no shares had been allotted, there would be no difficulty in raising the capital if a Provisional Order should be obtained.

Mr. MOULTON, Q.C., next spoke on behalf of the Chelsea Company and the Electric Power Storage Company, and urged that the great thing the Board of Trade should endeavour to do was to give the companies reasonable sized areas, so that they should have a local character and fulfil local duties. Dealing with the question of capital, he said there was no doubt the two large companies were going to make an attack upon the small companies on the question of capital. This question of capital was thoroughly gone into by the Board of Trade in 1883, when the question of the Provisional Orders came up, and the conclusions which were then arrived at were sound and satisfactory as applied to the circumstances of the present day. The substance of those conclusions was that the company must satisfy the Board of Trade that it had proper and sufficient capital to do its work, must appropriate the capital to the local use, and must, in nearly all cases, put down a portion of the capital as a guarantee that it was not idly taking up applications for orders without a substantial intention of carrying them out. It was not a question at that enquiry of the companies being bound to satisfy the inspector in any particular manner as to the sufficiency of their capital or of their power to appropriate it. There had been no evidence of any proposed mode of appropriation of the capital by any one of the companies. There was, as a matter of fact, not one of the companies whose capital was not much larger than the powers they sought under the orders. But the fact that the companies had this capital was not an appropriation of it to the purposes of the order, and the special and all-important point was included in what the Board of Trade decided in 1883, the appropriation of the capital to do the works necessary under one particular order and nothing else. The Board of Trade must be satisfied on that point, and the Electric Power Storage Company had already satisfied the Board as to its financial capital, and were ready to satisfy it as to its willingness to appropriate its capital to the purposes of the order. It was quite fair that the company should show what amount of capital was necessary for a large area, but it was a very different thing for it to have to show that any portion of it had been subscribed, and he contended that prudent, responsible men who intended to carry out the order if they obtained it evinced their wisdom in not having the capital subscribed before the orders were obtained, so that if the orders were not obtained the capital would not have to be returned. The Electric Power Storage Company had only raised £30,000, and with that had built a generating station which was large enough to supply all its new areas. The amount of the capital, however, was no criterion of the strength of a company's financial position until it was known how large an area the company proposed to light, and that was a very difficult thing to estimate when one company's applications for provisional orders included the greater part of London. The great point was appropriation, and his two companies were willing to appropriate the money to the local areas which they desired to obtain. The substance of the question was, Would the money be found, and were the undertakers persons fit to be trusted? Mr. Moulton had not concluded his address when the inquiry was adjourned until Monday.

(To be continued.)

ELECTRIC LIGHTING IN THE WEST.

THERE being a strong opinion at Plymouth in favour of the electric light, efforts are being made (as was intimated in the last number of the ELECTRICAL REVIEW) to form a company to supply the West with an improved system of lighting. The promoters of the present scheme, which is of a somewhat ambitious description, are determined not to spoil the ship for the sake of a ha'porth of tar, and have secured the services of the electrical adviser to the company which has already met with considerable success at Brighton, Eastbourne, and Kensington, the idea being to carry out an installation in the three towns on the same principle as has already been proved to be a success in other towns. Little doubt is entertained that the Plymouth Corporation will be prepared to assist the new departure, which would be likely to bring about a much needed improvement. It is proposed at present to erect a central station on some convenient site, and from thence to lay cables underground in six-inch cast-iron gas pipes, to supply the current to the principal streets and the residential portions of the town. Thus, the vexed question of overhead wires would not arise to harass the promoters of the enterprise. As far as possible the main roads will be avoided, but where it is found necessary to lay the cables in populous thoroughfares, they will be placed under the kerbstones of the pavement, so as to avoid interference with the traffic. When bye streets or lanes can be utilised, the pipes will be laid only twelve inches under the surface of the roadway. Every seventy yards there will be an iron box flush with the pavement or roadway, so as to facilitate repairs. It has not yet been decided what motive power will be used, but a careful examination is to be made to ascertain what water-power could be obtained from the Leat. In case the latter should be found to be insufficient, steam will be used. The high tension alternating current transformer system is to be used, and by this means the electricity will be able to be furnished at a distance of three or four miles. Should the scheme meet with the support of the Corporation and the town generally, it is stated that the Company will be able to supply the light at a price equivalent to 2s. 6d. per thousand cubic feet of gas. The promoters of the scheme are quite willing to enter into an undertaking with the Corporation to hand their works over to them within a given period upon equitable terms.

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

"On Lightning, Lightning Conductors, and Lightning Protectors." By Dr. OLIVER LODGE, F.R.S., member.

Introduction.

About this time last year I delivered two lectures to the Society of Arts on the subject of "Lightning Conductors," in pursuance of a bequest made to the Society in memory of the late Dr. Mann. In those lectures I abstained, as far as possible, from practical recipes and from anything like authoritative advice, contenting myself with calling attention to certain aspects of the subject which had been overlooked. I ventured to imply that none of the older electricians had any notion of the real conditions of the problem; that they all, from Franklin to Faraday and down to the present day, treated it as a much easier matter than, in fact, it is; and that there had been very little real progress in this particular department since the time of Franklin.

Recent advances in electrical theory made it easy for me to see further into the matter than the far greater men of the past had had any chance of doing; and a few very simple and easy experiments soon brought the conditions of the problem clearly before me.

It was these conditions upon which I laid emphasis in my lectures to the Society of Arts. Any practical outcome I left to a later period, and very likely to other hands. The first requisite seemed to be to grasp the conditions of the problem as illuminated by theory; the second, to carry out practical reform in the light of a large experience.

Such few practical recipes as I did surreptitiously introduce I fully expected to hear criticised, nor did I lay any stress on them at the time. (I may say, however, that I have seen no occasion since to importantly modify any of them, and that my position in respect of these practical hints is stronger now than it was then, inasmuch as I find that the large experience of the Belgian electricians, who have given more attention to this subject than perhaps any other school, has led them to recommend in recent years almost precisely the same methods of protection as those I advocated; their views being acquired almost entirely by practical experience, and scarcely at all by theory.)

The theoretical and experimental portions of my lectures were, however, matter of serious consideration with me, and nothing was set down under these heads but that of which I was absolutely sure. These portions have by all pure physicists been, so far as I know, universally accepted; as, indeed, they contain nothing but what any one of them could have easily arrived at had he happened to give sufficient thought and attention to the subject. They have not been attacked, nor do I believe they are at all attackable from the side of theory.

But from the side of experience an attack has come, and, strange to say, it has been directed, not at the few practical suggestions, which might be expected to be vulnerable on that side, but at the theoretical and purely scientific portions.

At the Bath meeting of the British Association, the then President of Section G, speaking in the light of a most gigantic experience—a personal acquaintance with over half a million conductors—led a most good-humoured attack against the doctrine of my lectures, and, exercising his well-known rhetorical and oratorical powers, succeeded probably in impressing the general bulk of the audience with the belief that he had, on the whole, the best of the battle; though, at the same time, I expect they were in a state of utter bewilderment as to what the conflict had been all about, and where the difference "'twixt tweedledum and tweedledee" precisely lay. The battle was, however, admittedly a drawn one, and at its close Mr. Preece magnanimously offered me another field, with an audience of an altogether different calibre to the general public of Bath, by getting your secretary to invite me to read a paper before this Institution.

Thus much by way of historical note and introduction. Now for the scientific portion of the paper.

I begin by running over some of the conclusions at which I arrived, and proceed to re-establish and demonstrate their correctness either by theory or by fresh experiment, whichever may seem the most simple and satisfactory under the special circumstances.

Two Main Cases of Lightning Flash.

1. All discharge is virtually that of a Leyden jar. There are always two conductors separated by a dielectric, and the discharge is a breaking down of the dielectric at its thinnest or weakest place.

In a thunderstorm the charged conductors are obvious, being either two clouds, or else a cloud and earth, and the dielectric is the air between.

2. It must sometimes happen, when one cloud discharges into another, that the potential of this other is suddenly raised high enough to cause it to discharge into the earth, even though no strain previously existed in the air between it and earth. The same thing may happen in various other ways when two clouds spark into each other.

3. There are, therefore, two main cases—(*a*) When the strain in the dielectric near the earth has been of gradual growth, in which case the path of discharge will be prepared inductively beforehand; (*b*) when the strain arises so suddenly that there is no time for any pre-arranged path. The first I call "steady strain;" the second, "impulsive rush." It is most important to recognise these two cases, and to understand the extremely different conditions attending the two. The first case only was ever contemplated by the older electricians; in fact, so far as I know, it was my experiments last year which first called attention to the other case.

Conditions of Protection and of being Struck, under the Circumstances of each Case.

4. I will now illustrate experimentally* the conditions under which discharge occurs in each of these two main cases, and I will take first the case of steady strain, or case *a*. This insulated sheet of tin plate is supported horizontally a foot or two above another plate lying on the table, and it is electrified by a Wimshurst machine. It represents a charged cloud hovering over the land, the lower plate representing the earth. Between the two I can erect buildings, and lightning conductors terminated in various ways. The typical terminals which I will here use to illustrate the conditions are four—viz., a large knob, or, as I shall call it, a "dome;" a small knob, which I shall call "knob;" a sharp point, and a gas flame, to represent a chimney or other furnace current of rarefied air. Putting the knob and the dome between the plates, we find the knob struck by preference, even though the dome stands at a much higher elevation. Introducing the point, we find it protects both, by a silent discharge, until it is lowered very considerably, and that then several points may protect when one does not. Replacing the point by the flame, we find that it protects, too, but not so efficiently as the point, and that it gets curiously beaten down and darkened in the act of protection. The point is not struck by a noisy flash until it is raised pretty close to the upper plate, when it is struck; but a bunch of points is even then not easily struck, sometimes continuing to discharge with a constant fizz right up almost into the cloud.

5. Try the effect of a bad earth or other very high resistance interposed in the path of the conductor, say a capillary water tube or a bit of wet rag or a wet string.

The violence of the spark is greatly lessened, and the sound is now gentle, but that which was struck before is still struck; resistance, so long as it be something short of infinite, makes no difference to the ease with which a given object is struck under the circumstances of this case 1. Insert the wet rag in path terminated by the point, and it still protects, practically, as well as before. Insert it in the path terminated by a knob, and it gets struck at the same elevation as before.

The fact is that the path of the disruptive discharge is all negotiated and pre-arranged in the air above, especially on the surface of any small conductor reared into this space, and the resistance which the flash may ultimately have to meet with in its passage to earth is a thing of subsequent consideration.

6. So much for the conditions attending case *a*, the steady strain.

* These experiments were shown with a splendid machine most kindly brought over and erected by Mr. Wimshurst himself, whom I hereby cordially thank.

Now attend to case *b*, the impulsive rush. We shall find everything very different.

Alter the connection so that a charged Leyden jar must, when it discharges, discharge direct into the upper insulated tin plate, and thence overflow to the ground if it is able to raise the potential high enough. If the plate is too far above ground for a flash to occur, the Leyden jar does not completely discharge; it only produces a number of fizzes and spits, and the greater part of its charge remains in it. But when the upper plate is within sparking distance of the ground (and the sparking distance under these circumstances is surprisingly great by reason of the impetus with which the electricity rushes into the top plate), then the jar discharges completely, and we have a violent crack both between the knobs of its discharger and in the air gap between the two plates, which is in the path of the discharge; the arrangement being really two condensers in series, but only one charged.

The only object of the Leyden jar in case *a* is to give more body to the flash. In case *b* the Leyden jar, or its equivalent capacity, is essential.

7. Putting the dome and the knob between the plates arranged as in case *b*, we find that one gets struck as easily as the other; the knob has now no advantage: whichever is the higher, that gets struck, without reference to other considerations. Introducing the point also, we find precisely the same is true for it; its protective virtue so much insisted on by the older electricians (among whom, I suppose, I am right in reckoning my chief antagonist), is entirely non-existent. It gets struck no more easily, and no less easily, than the dome, and it gets struck by a flash of precisely the same noisy character as the others get struck with. A bunch of points acts in exactly the same way. A comb of 24 needle points protects nothing, and gets struck just the same as anything else.

8. Now introduce the flame, and one notices a marked difference. In case *a* it protected less well than the point, but it was not struck noisily any more than the point was. In the present case it gets struck with violence, and it gets struck much more easily than anything else. Adjust dome and knob and point at about the same level, and they get struck, one or other, at random. Adjust the flame a great deal lower, and it protects them all, not by silent discharge, but by getting struck itself instead.

"Protection," however, is in this case not the word to use. The flame better represents a chimney requiring protection, while the point corresponds to the pointed terminal of a lightning conductor raised a good deal higher with the intention of protecting it. Protect it, it does not, however; the flash strikes down the column of hot air and through the flame, while it avoids the more lofty pointed terminal altogether.

Bring a point or a knob, or anything, *into* the column of hot air above the flame; *then* it gets struck easily enough, and protects the flame, but not if it is on one side of the hot-air column. The experiment has an obvious moral in relation to the protection of chimneys: It suggests that the Continental plan of a bar or arch across the mouth of the chimney may after all be justified.

9. Try the effect of resistance in the path of the discharger *now*, and we find it is altogether different to what it was in case *a*.

In case *b* things get struck according to their height, independent of the shape of their terminals, but not independent of their resistances.

Interpose a wet rag in the path of any one, and that one fails to be struck; it is not struck, and it fails to protect the others from being struck, even though it be reared up till it touches the top plate.

The top plate need not therefore be insulated at all carefully for this case *b* experiment.

Imitation of Lightning.

10. Now let us modify case *b* by making the top plate a sieve full of water, so as to get the flashes in a shower of rain. One cannot well try case 1 in a rain shower: the plate would be discharged too rapidly and continuously by the water drops for its potential to fully rise. But in case 2 the top plate is not necessarily charged at all until the rush comes, and so the rain shower does no harm.

Flashes in the rain can be got of surprising length and shape, for they make use of the water drops as stepping-stones. By adding salt to the water they become longer still, but there is no need thus to improve its conductivity for what I want to show.

Notice how the flash contorts itself, taking sometimes extraordinary paths as it jumps from drop to drop, but yet exhibiting its instantaneous character by showing the drops as stationary in its illumination.

11. Remove the things standing on earth plate just beyond fair striking distance, and what do we see? Appearances precisely like those which are observed in many lightning photographs.

A crowd of violet discharges fill the rainy air—forks, and branch and multiple flashes, not very bright or very noisy, but extraordinarily numerous, and striking on innumerable places at once. A movement is set up in this air at every attempt of the jar to discharge, exactly as happens in one of the most striking of the photographs belonging to the Royal Meteorological Society.

Masts and spars and deck and ocean may be simultaneously struck by these interesting flashes; and, though they do not here appear very violent, yet I expect that on the larger scale of Nature they are not very safe, and may easily have a heating effect sufficient to ignite bodies. These experimental ones are able to ignite gas in the midst of the rain.

12. While we have this arrangement at work we may as well try an interesting little experiment on what happens when lightning reaches water. The rain water has here been collected in a zinc tray some 3 inches deep, and by bringing a knob from the top plate, some 6 inches or so above the water, a flash strikes it. It prefers to strike anything metallic if it can, but if there is nothing else within reach it will strike the water. On reaching the water the flash forks out and ramifies in all directions in a crow-foot pattern, giving the same sort of appearance, only coarser, as that obtained by Mr. J. Brown by taking sparks on to a photographic dry plate and then developing.

Bring the knob nearer and nearer, the same thing happens, until the water is touched by the knob, and even after it is submerged. But as soon as the metallic conductor is submerged the ramifications get less and less vigorous, and when a sufficient surface is immersed they cease. I have never seen these ramifications spread of themselves *below* the surface of the water. They appear to me to keep entirely to the surface. But I have not yet finished investigating these appearances.

13. Immersing a half-full beaker in the water, sparks can be got to the water inside it, though they prefer to curl round and go outside. The noise the sparks make when they go inside is a curious one, and sounds as if the glass cracked each time, but it does not. If the glass is moist, a brush cascade round its edge can be seen in the dark. If it be dry, the water inside gets charged, and fizzes audibly back to the knob for a second or so after the spark has ceased, a dimple being visible in the water below the knob.

14. Live things in the struck water—worms, flies, fish, &c.—will most certainly get struck; but so they do under far less violent disturbances than what they would here be subject to. There is nothing surprising in the fish of a pond or lake being killed by a flash of lightning; and it has often happened.

When H.M.S. *Conway* was struck many years ago, and protected by its lightning conductors, it is related that the sea water was seen to be luminous on all sides of the ship. This is exactly the effect I now imitate.

15. There is one more experiment on discharge in water which I have just tried, and which it is interesting to show.* I take a pointed rod, and, protecting it by a glass tube, immerse its point under water in a beaker containing a plate connected to the other coat of the jar, and pass a spark. With the point negative there is a bright glow region round it every time, but the discharge is quiet. With the point positive the flash is of a dazzling white, and is accompanied by a great deal of noise and violence, threatening to smash the Leyden jar, and throwing down the copper plate towards the bottom of the beaker with fury.

Oscillatory Character of Lightning.

16. Before leaving the outdoor department of our subject I must say a few words on one branch of it, concerning which there is evidently considerable uncertainty and haziness abroad—I mean the oscillatory character of a lightning flash.

That a Leyden jar discharge is usually oscillatory must now be regarded as so abundantly proved that any doubts that may have existed on the subject must surely by this time be cleared away, at least for the case where the discharge has to utilise a wire circuit. But, perhaps, it is still doubted for the case when a jar overflows its edge, or, still more, when it merely sparks through its own dielectric, straight between the coatings.

Now, as I have insisted all along, a lightning flash is a spark through the dielectric of a jar whose two coatings are either two clouds or else cloud and earth. Hence, if any importance is attached to the fact (as I believe it) that lightning flashes are oscillatory, it is necessary to prove it for a Leyden jar sparking direct between its coatings, especially when the coatings are not very close together.

17. The reason I do attach importance to the oscillatory character of a discharge is because I have worked out the quantitative behaviour of conductors on that aspect of the matter; and though, as Prof. Fitzgerald said at Bath, everything would hold just as well for a single oscillation—viz., one violent rise and decay of current (which without any doubt *must* accompany a lightning stroke or any other quick discharge whatever)—if rapid enough, yet the rapidity of such a charge as this does not seem to me probably at all sufficient to account for some of the effects. The rapidity of variation of current in that case would be directly connected with the total duration of the flash; and though we have evidence that it is very momentary, yet we have no evidence that it is so instantaneous (say a millionth of a second) as the semi-period of one of the oscillations may be, a dozen or more of which may accompany an entire flash. However, I admit, of course, that all I want is a tremendously rapid variation of current; and if I can be given this by one oscillation, the rest are unnecessary, and may be dispensed with.

18. When I speak of the oscillatory character of a flash, let it be understood once for all that I do not mean in the least such a thing as can be analysed by waggling the head. Flashes analysable by waggling the head must be multiple ones, and the interval of time between their constituents (which may be, say, the fiftieth of a second or thereabouts) is a long period compared with that of an oscillation such as I mean, bearing the same sort of ratio to it as a quarter of a century bears to an hour.

19. A direct experimental proof that lightning is oscillatory will be obtained when photographs of it are taken on a sensitive plate revolving 1,000 times a second. Something short of that speed would cause the image of the flash to blur, but that speed

* This experiment was not shown at the meeting, because in trying it over in the afternoon the protecting glass tube was electrically broken.

might be sufficient to analyse out the oscillations, when examined carefully with a magnifier, the focussing being good.

Till then the easiest proof that it is oscillatory is a theoretical one, and it can be put in a few words.

20. Consider an air condenser with two coatings, each of area, A, separated by the distance, h, and let it burst its dielectric. It is well known that the discharge is oscillatory when the whole resistance met with by the discharge is anything less than a critical value.

$$R_c = 2\sqrt{\left(\frac{L}{S}\right)}.$$

Now, attending only to the straight part of the discharge, and ignoring the current rushing up in the plates to the spark path, the self-induction of a straight conductor of length, h, and sectional radius, a, is very approximately

$$L = 2\mu h \log \frac{4h}{a}.$$

The capacity of the discharged condenser is

$$S = \frac{K A}{4\pi h}.$$

Hence the critical resistance which must not be exceeded is given by

$$R_0^2 = \frac{32\pi\mu h^2}{K A} \log \frac{4h}{a};$$

or

$$R_0 = 10\mu h \text{ "}v\text{"} \sqrt{\left(\frac{1}{A} \log \frac{4h}{a}\right)}$$

$$= 300 \text{ ohms} \times \sqrt{\left(\frac{1}{A} \log \frac{4h}{a}\right)} \times h.$$

The important thing to notice in this value of $\sqrt{\frac{L}{S}}$ is that it is approximately proportional to the first power of h, the distance between the plates of the condenser.

21. Next consider the resistance of the discharge path. It, too, will be proportional to the length, h, and it may be written

$$R_1 h,$$

where R_1 is the resistance per unit length of the discharge path.

The condition for oscillation, then, is that this $R_1 h$ shall be less than R_0; or *the resistance of unit length of the spark must be less than*

$$300 \text{ ohms} \times \sqrt{\left(\frac{1}{A} \log \frac{4h}{a}\right)}.$$

22. The term under the square root will take different values according to circumstances, and it may be greater or less than 1 per metre. Ordinarily, however, it will be greater than 1 per metre, unless the area of charged surface is considerable. The important thing is the way in which h, the distance between the plates enters into the expression. It does not come in very prominently at all, but so far as it does influence the result it permits the discharge to be oscillatory more easily when the plates are a good distance apart than when they are close together.

23. Take a couple of typical examples.

First. A Leyden jar bursting its glass. A fine needle may be just put through the hole usually made in these cases, so we can take the sectional radius, a, as something like a tenth of a millimetre. The thickness of the glass may be 2 millimetres, hence $4h/a = 80$ or thereabouts; and the natural logarithm of this is about 4. Suppose the area of coated surface is half a metre square, then the critical resistance which a metre of the spark must not exceed is 1,200 ohms, and so the 2 millimetres of it must not exceed 2·4 ohms.

It is difficult to say whether this is or is not a large resistance for such a short spark, and hence it is difficult to be sure that such a spark is anything more than a mere one-directional discharge. To go into it more fully the currents in the metal coatings would have to be considered.

Next take as example a cloud area at an elevation of one kilometre; and because a lightning discharge usually makes perforations of fair diameter, we may suppose a to be about a millimetre. (A widely erroneous estimate in this quantity makes but little difference in the result.) In such a case $4h/a = 4 \times 10^6$, and the logarithm of it is between 15 and 16. Hence the charged area may be 15 or 16 square metres without bringing down the square root term below 1 per metre; so the resistance of the whole flash may in that case be anything below 300,000 ohms without checking the oscillations. The discharged area may indeed be as much as 1,500 square metres without bringing the critical resistance which the flash must not exceed below 30,000 ohms, or 30 ohms per metre. (Understand that "resistance" here does not mean impedance. It means true dissipation of energy resistance (sec. 25), and the current squared is so enormous (sec. 29) that the resistance coefficient may be quite small.)

In another place (*Phil. Mag.*, August, 1888), I have shown reason for believing that the area of cloud discharged at any one flash is usually very moderate; and hence on the whole I consider it proved, so far as elementary theory can do it, that the lightning flash usually takes place under conditions favourable to oscillation.

24. And these oscillations are extremely rapid. The rapidity depends on the inverse geometric mean of L and S, and this is practically almost independent of h. Referring back to their values, we see that

$$L S = \frac{\mu K A}{2\pi} \log \frac{4h}{a};$$

and so the number of complete alternations per second is

$$\text{"}v\text{"} \sqrt{\left(2\pi A \log \frac{4h}{a}\right)},$$

which, in the second example of section 23, with A as 100 square metres, becomes

3 million per second.

If the discharged area were as great as 10,000 square metres, the rate of alternation would still be a third of a million per second.

Material of the Lightning Conductor.

25. A few words may suffice to explain the nature of the impedance which alternating currents meet with in passing through a conductor, and of the reason why iron is as good as, or even better than, copper for the purpose of conveying currents alternating with extreme rapidity.

A rising current has to magnetise the space all around it, and the production of this magnetisation delays and impedes the rise of the current to its maximum value. A falling current permits the magnetisation of the space all round it to decay, and the dying out of this magnetisation delays and impedes the fall of the current to its minimum. The more rapidly the current changes, the more powerfully felt is the influence of the accompanying magnetisations and demagnetisations. Now the total magnetisation produced by a current—its total number of lines of force, or its total "magnetic *induction*," as it is often called—is proportional to the current strength; equal to it multiplied by some constant, which we may call L, and write

$$I = L C,$$

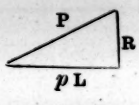
where I is the total induction produced by the current, C. L is a coefficient characteristic of the circuit, its value being defined by this equation, and is called the coefficient of induction excited by the current's own self, or the coefficient of self-induction.

If the current goes through $p/2\pi$ complete alternations in a second, it can be shown that the impedance it meets with, due to the reversals and re-reversals of its own magnetic field, is p L.

This is not the whole obstruction it meets with, but it is the only part which does not dissipate energy and cause its vibrations to decay. It may be called the *inertia* part of the impedance. The remaining part of the total impedance is resistance, R, the dissipation of energy coefficient, defined by

$$\text{heat per second} = R C^2;$$

and the total is the resultant of these two as if they were at right angles to each other. So that, calling P the total impedance,



$$P^2 = (p L)^2 + R^2.$$

Now in respect of the R term, iron is much worse than copper, not only 7 times worse, hundreds of times worse; but then for very rapid alternations the R term is altogether insignificant compared with the p L term.

26. In respect of the p L term does the material of the conductor matter?

Well, in so far as the magnetisation spoken of is that of the space surrounding the conductor, of course the substance of the conductor itself matters nothing. But in so far as the conductor itself gets magnetised, the material of which it is made does matter. Now a linear current magnetises at right angles to itself everything surrounding it—most intensely the things close to it. A hollow cylindrical current magnetises everything outside itself, but nothing inside. If the current were to distribute itself uniformly through the section of the wire, the outside of the wire would get magnetised in concentric cylinders; but if the current were to confine itself to the outer surface, and flow as a hollow cylinder, it would escape the necessity of magnetising the wire at all. In cases where the p L term is much more important than the R term this is precisely what it does therefore. It always flows so as to meet with the least possible total obstruction; and it finds less total obstruction by cramping itself into the periphery of the wire than it would find if it utilised the whole section. The cramping into the periphery increases R, but it decreases p L, and on the whole, with rapidly alternating currents, this is an advantage, and gives a smaller value to P.

Slowly changing currents think most about R, and use the biggest cross-section they can find. Rapidly changing currents think most about p L, and avoid having to magnetise more than they need. Especially must they avoid having to magnetise the conductor if it consists of iron; hence, in that case, they cramp themselves tremendously into its outer skin, and thereby avoid having to overcome much more total impedance than they meet with in the case of copper; but though they thus keep down impedance, they increase their dissipation of energy term, and get their oscillations damped out far more quickly than when they only have to pass through copper. The violence of the flash therefore subsides more quickly in an iron, than it does in a copper, conductor, and so I find it experimentally.

Nothing here said is in the least hypothetical. It is all absolutely clear and certain, and has been abundantly verified. I will not go into the history of the subject. It is well known.

27. Let it be clearly understood, once for all, that in comparing copper and iron conductors I never mean comparing them as of unequal thickness, *i.e.*, of equal conductivity. Such a comparison is ridiculous in the present state of knowledge. They are to be compared when of the *same* thickness; and under those circumstances I assert iron to be a trifle better, certainly not a whit worse, than copper, irrespective of all its other manifest advantages, cheapness, fusing-point, &c., &c. Want of flexibility is sometimes urged against iron, but stout telegraph wire is flexible enough; and, until experience decides to the contrary, I feel sure it is thick enough for lightning conductors.

The one and only thing on which anything can be said against iron is on the subject of its durability; and this being a chemical question, I offer no positive opinion; at the same time I am absolutely certain that any slight disadvantage in that respect is a hundredfold compensated in most localities by its other superlative advantages.

Current and Potentials during Discharge.

28. In cases where a conductor is pretty thick, say, anything like a quarter inch diameter, or even a tenth, and of any moderate length, such as 100 yards or less (not many miles), the two terms of impedance are so unequal that it is for many purposes needless to think about R at all, the impedance is practically $p\,L$ simply; and this, as I have shown in *Phil. Mag.*, August, 1887, is, under any given circumstances, half the critical *resistance* which determines whether the discharge shall be oscillatory or not under the same circumstances. The total impedance is commonly to be reckoned in hundreds or even thousands of ohms.

29. The strength of current passing in the alternations can be estimated by considering that the whole quantity stored up in the discharged body has to be transmitted in a quarter of one oscillation period—say, for instance, in the millionth of a second. If the quantity discharged were one coulomb, this would mean a current of a million ampères. In any case the current must be hundreds or thousands of ampères.

30. The difference of potential needed to drive so strong a current through so great an obstruction is enormous, being equal to the product, $P\,C$, and may be reckoned in millions or hundreds of millions of volts; hence it is that lightning conductors afford no easy path for lightning, but that it tends to fly off in all directions, even to what would seem, and indeed are, very inferior conductors. It will spit off from a well-earthed stout copper rod to bits of wood and to perfectly insulated bodies.

Effects in the neighbourhood of a Discharge.

31. Putting together the enormous electrostatic potentials existing at the different points of a conductor conveying a discharge, and the violent oscillation to which so strong a current is subject, we perceive how great must be both the electrostatic and the electro-magnetic induction in all space anywhere near it.

These disturbances, thus rendered certain and accounted for, can easily be experienced experimentally. I proceed to relate a few experiments out of a multitude which I have made.

32. I took a considerable length of highest conductivity No. 0 electrolytic copper wire, kindly lent me by Messrs. Thos. Bolton and Sons, and arranging one end so as to be accessible to Leyden jars, &c., carried the wire up to a high gallery and then down to earth. Earth was made in several ways on different occasions: water pipes, gas pipes, hot water pipes which ramified the whole building, outside gas mains, bars buried in ground; but the most effective and indeed perfect return circuit could be had when wanted by connecting the end metallically with the outside coat of the jar, without any earth contact at all. When this direct contact was not made, the outer coat of jar had of course to be connected to earth also, in order to complete the circuit. Very often they were both connected to each other and to earth as well. It makes no essential difference; whatever may be considered the most satisfactory method, that may be adopted, and the phenomena will go on just as well. They may be briefly summarised as follows:—

(1.) If the conductor pass within an inch or two of any uninsulated piece of metal it gives off a violent side flash to it.*

If the far end of the conductor is neither earthed nor connected to jar, but is left insulated in air, side-flashing from it occurs a trifle more easily, but not very markedly so.

(2.) If the conductor pass within, say, half an inch of an insulated conductor, it gives off a side flash to it; the strength of the flash depends on the capacity of the insulated conductor, being considerable if it be large; but some side spark occurs to an absurdly small body perfectly insulated, *e.g.*, such a thing as a coin on a stick of sealing wax; and this when the conductor is absolutely well earthed at its far end.

(3.) Sparks can be obtained from everything, even quite uninsulated things, connected to the conductor: for instance, if it be connected to the gas pipes, small sparks will fly to the finger or to an insulated body from all the gas brackets about, and these sparks are sufficient to ignite gas.

(4.) Sparks can be obtained between the ends of any long curved conductor, be it insulated or uninsulated, if they are brought close enough together to form a nearly closed circuit.

(5.) Sparks can be obtained from or between insulated bodies in the neighbourhood of the conductor, and not connected to it at all, every time a flash occurs.

For instance, a large piece of wire gauze connected to nothing gave off sparks to a gas bracket and ignited the gas. Moreover, one piece of wire gauze sparked small sparks into another, neither connected with anything.

[*In illustration of this, some gilt key-pattern high up on the wall of the hall was seen to be sparking while Leyden jar discharges were going on through a wire lying on the floor. They were not so bright as the sparkings in the Royal Institution wall paper, but the gilding was further from my wire, and, I believe, is quite far from any wire. As illustrating the electric currents produced in conductors during the act of reflecting electro-magnetic waves, they were therefore still more satisfactory.*]

(6.) Sparks can be obtained from quite uninsulated bodies, even when not connected with the conductor: *e.g.*, from hot water pipes, from gas pipes, from water pipes, from strips of brass let into the table, from gas brackets in other rooms, from a wire lying on the floor of a distant corridor; and, in fact, all over the building with few exceptions. The sparks can be taken by a penknife held in the hand; sometimes they can be taken to the knuckle or finger-tip even when pressed against them.

(7.) Sparks can be got to pass between two totally uninsulated things, neither of which have any connection with the lightning conductor. For instance, let the conductor be thoroughly earthed in some outdoor and distant manner, and under favourable circumstances a bright short spark can be seen passing at every discharge between a gas-tap and a water-tap of my lecture table, which happen to approach each other closely. Let the gas escape near these sparks and it ignites.

(8.) Sparks can be got between two thinly insulated electric light wires if they lie close enough together, and if a storage battery be connected to them an arc will be started, destroying the insulation and burning the wires.

(9.) If at any distant place, or out of doors in daytime, the sparks are too feeble to be seen, disturbances can still be easily detected by means of a telephone; connecting one terminal to the thing—say, the roof of a shed, or a wire fence—and holding the other end in one hand. Or, of course, by connecting the two terminals to two different things, or to different parts of one thing.

(10.) Arrange Abel's fuses between gas and water pipes, between pieces of wire gauze and gas pipe, between hot water pipe and a bit of sheet metal, between the lightning conductor and a 6-inch metal sphere on long glass stem, between two large insulated bodies, between the gas bracket of another room and an empty Leyden jar; in short, in almost any place, likely or unlikely. Then take a few strong discharges through the thick copper rod with end well earthed, and the fuses will pop off, some at one discharge, some at another. Very visible sparks can sometimes be seen passing into the fuses, if they be not closely connected, without exploding them. A certain energy of spark is necessary to ignite the composition; much more than is sufficient to excite the retina.

Lightning Protectors.

33. Now let me say a word about the possibility of protecting telegraph and other instruments from damage by lightning currents which may have entered the aerial lines.

There is indeed no guarantee that burying wires beneath a pavement, or even beneath water, will effectually secure them from lightning disturbance, as I have now fully illustrated, but certainly overhead wires are more exposed.

The ordinary and well-known form of lightning protecting arrangement is to attach a pair of plates, or a double set of points, or a pair of points in a vacuum, or some other small air space, as a shunt to the instrument or coil of wire to be protected. Here are arrangements of the kind. Now it is perfectly easy to see that the protection such things afford is of the most utterly imperfect kind.

Take a coil of tangled silk-covered wire, or any other coil that you don't mind damaging, and attach it as a shunt to one of these protectors. On discharging a jar through it, the insulation of the coil is pierced in heaps of places. Or one may use a short fine wire, and see it deflagrated by the branch discharge.

34. It may be said that my air space is too wide. Very well, then, abolish it altogether. Bring the plates of your protector into direct metallic contact. By so doing, the coil is indeed shunted out of the circuit, and if it were a telegraph instrument no signal could be given, for no appreciable fraction of the current takes that route; but with a Leyden jar flash it is otherwise. Although the plates of the protector are in contact, soldered together if one pleases, and led up to by stout wire or rod, a branch flash still breaks through the insulation of our wire tangle, or deflagrates our little bit of thin wire.

35. It will be said the joints are bad. Well, then, do without joints; take a stout rod of electrolytic copper bent in an arc, say, 2 feet long, and, bridging it across with the wire tangle, discharge a jar round it. Still a portion takes the thin wire, even though it offers a path yards in length.

Take a straight bar of copper an inch thick, and arrange an invisibly fine Wollaston wire of greater length as a tapping circuit. Some of the discharge shall leave the bar, and spark across a minute air gap at each end, in order to make use of the hair-like platinum wire.

Go further still than this. Connect a coil of thin-covered wire *by one end only* to a wire conveying a discharge, standing the reel

* This easy and striking experiment I stupidly omitted to show at the meeting.

upon a block of paraffin or other good insulator, and connect the other end to any little thing of any capacity at all—say, a bullet lying on the block of paraffin: you can see sparkings through the insulation of the wire on the reel at every discharge.

These experiments render manifest the hopelessness of any simple shunt arrangement as a lightning protector.

36. The easiest mode of exhibiting the essentials of these experiments, one that can be tried by anyone possessing a Leyden jar, a pair of discharging tongs, and a yard or two of fine silk-covered wire, is to hang a tangle of the wire loosely on to the tongs, not necessarily making any sort of good contact, and then use them to discharge a jar in the very ordinary way. Some of the flash will take the thin wire, and will spark through the insulation at a number of points.

37. It may be very well objected to me that it is pretty useless if I only point out the imperfection of present methods, and offer no suggestion as to a proper lightning protector. Well, this struck me too, and the result is that I have devised and made what I think I may call an absolutely perfect protector—one into which great flashes may be sent, and yet the galvanometer or instrument intended to be protected shall not wink, nor shall the slightest palpable or visible disturbance be discernible, notwithstanding that complete metallic contact is maintained all the time, and not a trace of the signalling or useful current wasted.

The thing seems so good that I am making it the subject of a patent, and you will therefore pardon me for saying no more about it just yet.

38. The next part of this paper is largely controversial. I do not take much pleasure in this portion, and wish it were unnecessary. But it is a purely impersonal controversy; and so long as the old-fashioned views are in existence, one way of arriving at the truth is to try and thrash them out of existence. If there is any real vitality in them the attack will fail. It will be well believed that I have no feeling of hostility to the Lightning Rod Conference, when my best scientific friend, Prof. Carey Foster, was one of its members. Had I been one myself, I no doubt should at that time have signed the very documents which now, in a few places, I criticise. Had I indeed so signed, I would abuse what I now see to be its erroneous portions with still more vigour than I now permit myself to employ.

(To be continued.)

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1888.

17224. "Improvements in and relating to electrical apparatus for propelling tramway and other vehicles." L. PAGET. Dated November 27. 8d. Relates to apparatus for drawing or driving tram-cars and analogous vehicles through the agency of electricity, and its objects are, first, to make the application of electrically controlled power to existing lines of tram-cars and analogous vehicles possible without any change in either the rolling stock or its appurtenances and in such manner as to obtain great efficiency. Second, to provide means for the control of the said power, which shall be simple, efficient, and capable of use for other purposes on the lines where used than the mere propulsion of the cars and the like, as to clear the track of snow or dirt, and in short to utilise the applied power in numerous ways apart from its mere application as a means of propulsion. Third, to provide simple and efficient clutch and switch connections for connecting the propelling electrical motor to the motor which moves the car or cars, and also to provide additional means for increasing the security and efficiency of said electrical motor and the source of electrical supply which gives it motion. The claims are 8 in number.

17225. "Improvements relating to the generation of electricity and the simultaneous production of zinc chloride and other bye-products." L. PAGET. Dated November 27. 8d. Relates to the art of generating electricity by voltaic means, and its object is to cheapen the production thereof. The inventor accomplishes this object by the processes described of creating valuable bye-products, which bye-products may be placed upon the market and sold as merchantable articles. The claims are 5 in number.

CORRESPONDENCE.

Alternating Current Machines.

In your issue of April 18th we notice a letter from Messrs. Ganz & Co., in which they refer to a statement made by Prof. Forbes in his recent paper on "Central Stations in Europe," that an alternating current dynamo, manufactured by us, is a copy of one of their old type machines.

We are sorry that the discussion on Prof. Forbes's paper has not yet been published, as the facts given by Mr. Preece would have shown Messrs. Ganz that our latest machine is only slightly different in details from a machine patented and built by us in 1882, and p... to their patent. We enclose photographs of the ... machine, which has a stationary armature with ... coils laid on the inside, and revolving field mag... similar to our machine of 1888, of which we also enc... photo. Machines built in 1882 to the first patent ... very successfully, but at that time there being no ... for alternating current machines, excepting to ... Jablochkoff candles, not much was done with the... until the advent of the transformer.

For Elwell-Parker, Limited.
T. PARKER, *Director.*

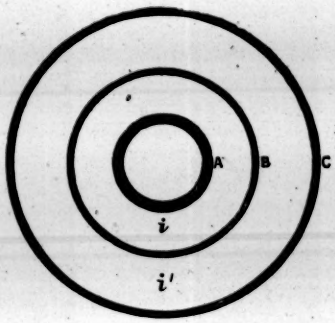
April 27th, 1889.

[We hope to reproduce these photos in an article later on.—EDS. ELEC. REV.]

A Conductor for High Potential Currents.

Ferranti's method of conveying the current fro... Deptford is probably a good one, and may turn out ... be efficient. But as no such current has been conveyed ... as he proposes sending, we must wait until operations ... are commenced before giving too decided an opinion as ... to the insulation, &c., of his conductors. The jointings, ... I must say, appear to be a very serious matter.

Instead of using two tubes, which must always admit ... of a direct or indirect air connection, would it not be ... a good plan to employ three, the middle one, B, being ... a dummy, merely to stop any direct air passage between ... the real conductors, A, C. The dummy might be of



iron, unless required for lower potential currents. And in making the joints, before injecting the insulating material under pressure, would it not be advantageous to exhaust the air as far as possible, or provide for its escape under the pressure? The insulation is represented by *i*, *i'*.

Talking about copper tubes as electric conductors, I should like to know if the following plan has ever been tried for passing strong currents through small conductors, viz.:—To use a tube or tubes with the insulation on the exterior, and a constant circulation of water within to keep down the temperature, &c.

James C. Richardson.

April 29th, 1889.

Semi-Invertible Cells.

I notice in your issue of the 26th inst. a description of a semi-invertible cell brought out by Messrs. F. Geere Howard, which is spoken of as something novel, whereas I constructed and supplied many cells on this same principle some three years ago.

Gus. L. Franke.

April 30th, 1889.

[Our correspondent doubtless refers to the cells of Mr. Barber Starkey, who does not claim anything novel in the principle of turning a battery partly over to put it out of action. Mr. Franke has evidently misunderstood the points to which we drew attention.—EDS. ELEC. REV.]